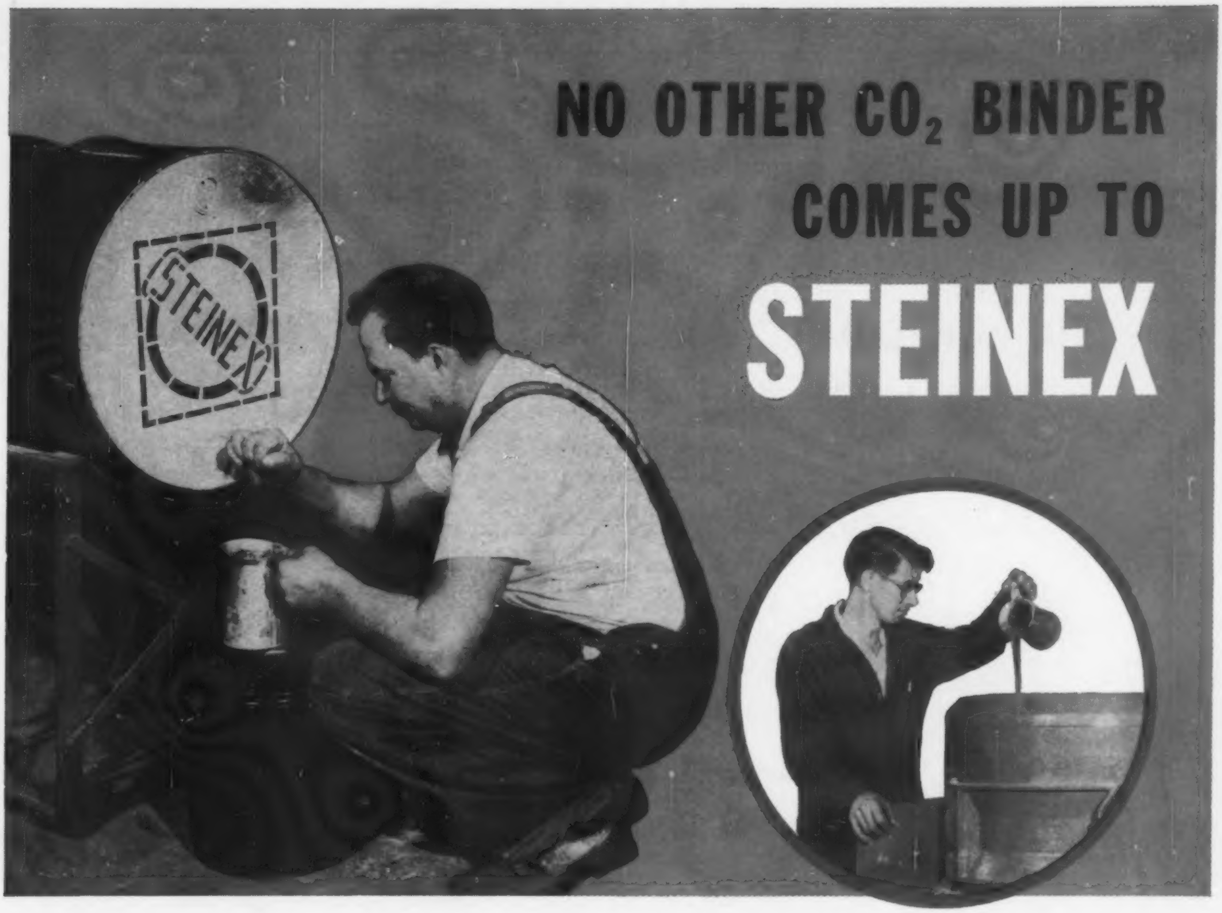
DECEMBER 1961

modern castings

the technology-for-profit magazine

Casting A Heartbeat Page 36



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Circle No. 121, Pages 133-134

APEX SMELTING COMPANY ANNOUNCES THE MOST SIGNIFICANT ALLOY DEVELOPMENT IN ITS 38-YEAR HISTORY

Aluminum Alloys for die casters now part of Allcast line

For years Allcast 70, developed by Apex laboratories, has been the alloy that sand and permanent mold foundries prefer for their difficult jobs to achieve consistently high fluidity, absence of shrinkage, pressure tightness and a consequent high yield with a minimum of rejected castings.

Recognizing that die casters, too, had need of an alloy possessing not only these characteristics, but also offering minimum sludging and soldering, Apex's technical staff experimented with a variety of alloy heats and additives. Yet, after hundreds of tests, the elusive goal of consistent results had still not been achieved.

Then, early this year, Apex's technical staff was elated to hit upon new refining and alloying procedures that held promise of yielding the desired results.

Would the resulting alloy stand up under "tough job" conditions in the field? To get the answer, Apex enlisted the help of a number of its die casting customers and asked them to put the new alloy to the test. With shipment after shipment, on a consistent basis, these customers reported obtaining benefits such as these:

- **Increased fluidity**
- **Minimum sludge formation**
- **Less porosity and cold flows**
- **Less lubricant required**
- **Less tendency to solder**
- **More shots per hour**
- **Lower casting temperatures**
- **Extended die life**
- **Brighter surface finish**
- **Better machinability**
- **Greater pressure tightness**

Though the new alloy appeared assured of acceptance, another big obstacle to practical adoption still remained—the substantially higher production costs of the new refining and alloying procedures. It remained for the Apex executive committee to resolve this problem by authorizing the expenditure of up to a million dollars for plant modernization and new equipment whose greater efficiency is expected to offset the increased costs. At the same time, the executive committee authorized immediate adoption of the new procedures, with Apex absorbing the higher costs.

Apex Allcast aluminum die cast alloys, prepared in conformance with standard or custom specifications, are now available at Apex's Chicago, Cleveland and Los Angeles plants.

APEX SMELTING COMPANY

Chicago 12 • Cleveland 5 • Long Beach 10, California
Springfield, Oregon (National Metallurgical Corp.)

Research leadership back of every ingot

Circle No. 122, Pages 133-134

December 1961 Vol. 40, No. 6

modern castings

metalcasting "technology-for-profit"

COVER

Drawn by CHARLES ROTH. Investment-cast heart valve plays a key role in this medical advance. See story on page 36 for further details.

JANUARY ISSUE

Market Opportunities Exist in Construction, Mining Fields
High-speed Mold and Weight Transfer Saves Labor
Cutting Costs with Furan No-Bake Cores

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CORE MAKING METHOD									
BINDER	CHEM-REZ "100"	CHEM-REZ "100" with LINOIL	CHEM-REZ A-200	LIN-O-SET	LINOIL	ADCOSIL	ADMIREZ PHENOLIC	ADMIREZ PHENOLIC	ADMIREZ UREA
PROCESS	HOT BOX	OVEN BAKE	NO BAKE	AIR SET	OVEN BAKE	CO_2	SHELL	OVEN BAKE	OVEN BAKE
CURING PRINCIPLE	Chemical & Heat	Chemical & Heat	Chemical	Catalytic, Oxidation & Heat	Heat	Chemical	Heat	Heat	Heat
RANK in relation to:									
ACCURACY (Core dimensions)	4	2	1	1	2	1	1	2	2
SPEED OF PRODUCTION (output per worker)	1	3	5	6	4	2	2	4	1
ECONOMY (Sand Mixture)	3	2	7	6	1	4	7	5	2
CONVENIENCE (Handling, Tooling or Precautions)	1	5	3	4	5	2	2	5	5
SIMPLICITY (Core quality Control)	2	1	5	6	1	4	3	1	1
VERSATILITY (Range of metals & core type)	2	2	4	4	1	5	3	3	4

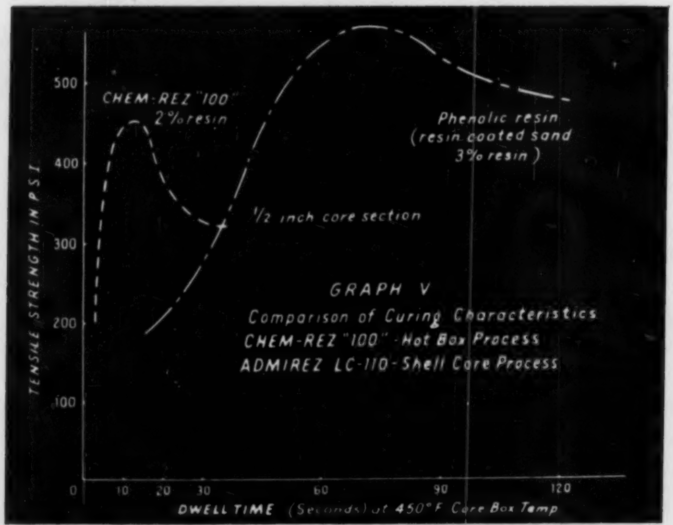
NOTE: Rankings given are in terms of "order of preference." No attempt is made in this comparison table to rate the various processes in terms of their relative value in each functional category.

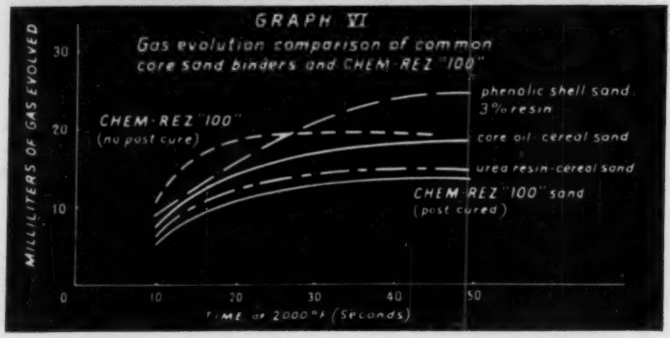
CHEM-REZ "100" RANKS FIRST in VALUE ANALYSIS of nine different types of ADM core binders!

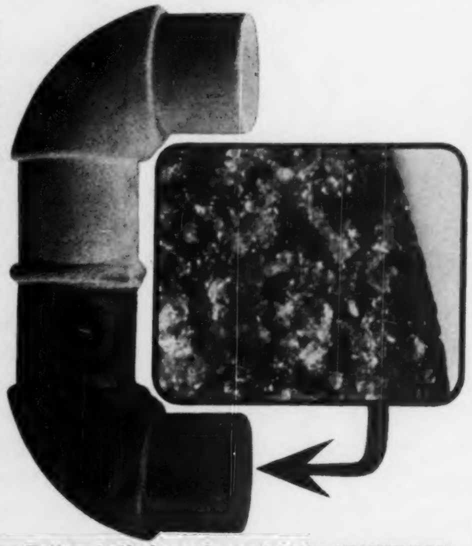
A comprehensive technical bulletin on CHEM-REZ "100" has been published by ADM to keep foundrymen up to date on the latest performance and application data. A copy is yours for the asking.

Graphs V and VI (below), taken from this 16-page bulletin, are typical of its contents. Other charts and tables cover: sand mixtures and cycles; core box temperatures; effect of resin and catalyst content; comparison of various types of catalysts; effect of core section thickness on tensile strength build-up; and comparative high temperature properties of CHEM-REZ and oil and cereal cores.

Also discussed is the application of CHEM-REZ "100" to various curing techniques such as: hot box; combined core oil and resin; oven baking — conventional, dielectric, infra-red, or re-dry. Write to ADM for your copy.







Bottom half of core is coated with VELVAWASH CR-100 . . . the wash that's MATCHED to CHEM-REZ "100" cores.

Twenty-power magnification above shows CHEM-REZ "100" hot box core coated with VELVAWASH CR-100. This wash clings tightly without excessive penetration which would deteriorate surface hardness. Write for information.

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Archer-Daniels-Midland

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Circle No. 123, Pages 133-134

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Let's look at . . .

TECHNOLOGY AND MARKETING—NATURAL PARTNERS

H. E. Green

TECHNOLOGY is of no value to metalcasters today unless it can be put to work producing profits for them. It must result in improved equipment, supplies, processes and methods which make operational profits and sales possible. It must stimulate sound marketing practices.

Unless there is a close linkage today between new technology and sound marketing, the metalcasting industry can go nowhere but down. Only firm action can turn profits upward.

This is why MODERN CASTINGS, as the natural voice and conscience of the industry, is crusading for a speed-up in the application of better marketing principles to the castings produced by *today's* technology.

— Our next MC Trends Seminar will deal with marketing's relationships to metalcasting technology. This will be at the Southeastern Regional in February.

— On page 122 of this issue you can read about Tom Barlow's leadership talk on marketing at the Purdue Regional. On page 123 you'll find how seminar participants at the New England Regional emphasized marketing.

— On page 50 of last month's issue, November MODERN CASTINGS, you can read how 86 per cent of MC's trends panel metalcasters favored greater emphasis on marketing know-how this coming year, 1962.

— On page 141 of MC's October issue, you read *first* about the stimulating results of the Second Marketing Conference sponsored by International Minerals & Chemical Corp. and Hickman, Williams & Co.

Every issue of MODERN CASTINGS deals with marketing opportunities for metalcasters in various metals and in end-user markets. We have the technological means to capitalize on these opportunities. But it is marketing know-how which is the logical follow-through. Technology and marketing must join hands. A united program is needed!

Leading metalcasters who know marketing can help. They must unite with leading equipment and supply manufacturers, who have marketing know-how, and who are helping already in many ways to create markets and greater sales for metalcasters. Then this industry CAN go places! *It MUST be done! What will you do* to help?

Harold E. Green

Circle No. 124, Pages 133-134

Looking at Business with Modern Castings

1962 OPTIMISM

Most bellwether leaders in the industry, metalcasters and suppliers, continue optimistic about 1962 business prospects. Some capital goods suppliers are concerned about 1962 business prospects for the first quarter. (See report on page 118 about annual meeting, Foundry Equipment Manufacturers Association.) But this stems from a tendency for new equipment business from metalcasters to lag behind other facets of metalworking. It must be remembered that two factors have been contributing to a distinct softness in metalcasting at this time!

1. The automotive strikes, which reflected definitely on all industry.

2. An unusual weakness in metals prices, which have been drifting steadily down. At this writing, spot metals prices are back where they were in June. Tin is queasy. Lead is the lowest in years. Copper is beset by lower prices, especially because of foreign market conditions. Steel scrap is down. Price cutting is current at present in aluminum.

Add to this an unusual amount of year-end "economizing" by many metalcasters, and December seems slated to end on a soft note.

ORDERS

If metalcasters want a key indication, since the industry is a "parts supplier" to many industries, they should look to machinery and equipment orders. The picture for 1962 is good. The only revision which might affect the pace is timing. January, February and March will be key months to watch. Indications now are that many metalcasters are taking an "order vacation" until the new year begins.

AUTOMOBILES

Watch the automotive industry. Dealers <u>are</u> optimistic. The used car situation means better trade-in deals. Auto installment debt is down. Consumer acceptance of new cars is fairly well across the board. There's no denying that the automotive industry alone can have tremendous impact on metalcasting.

The key is sales effort required by companies and dealers. The need for sales push may be a blessing in 1962. A cautious attitude about business improvement may result in better marketing efforts by all phases of manufacturing. <u>Metalcasters should make sure they're not left at the post by marketing-minded competitors -- forgings, weldments, plastics.</u>

STEEL

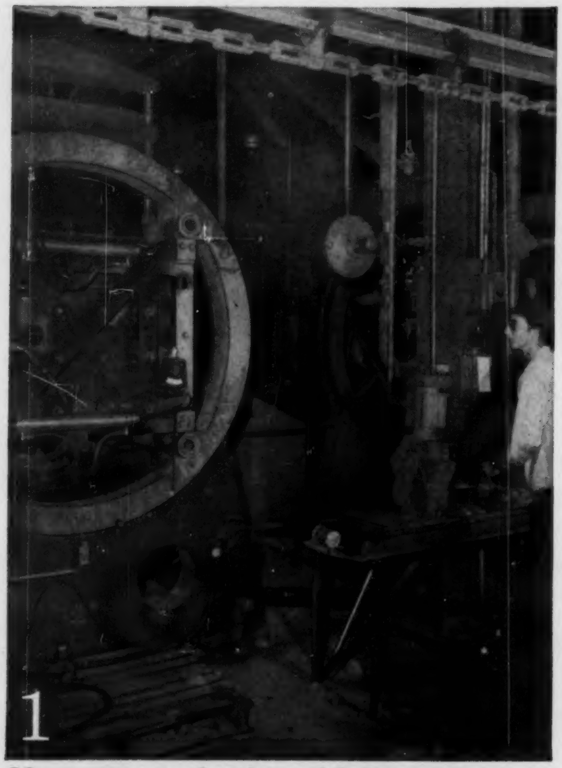
The advice of Joseph L. Block, Chairman of the Board of Inland Steel, provides a pointed reminder. Speaking before the Controllers Institute of America about shrinking profits and rising costs (certainly a situation typical of metalcasting), he said that the industry is striving to cut its costs through research and more energetic sales campaigns. But he also emphasized that productivity increases will be primarily dependent on the investment of capital in new and better methods and machinery. This is dependent on the profitability of the industry.

Incidentally, don't expect steel output to start pushing up until early January. Then expect a spurt in anticipation of labor-wage talks.

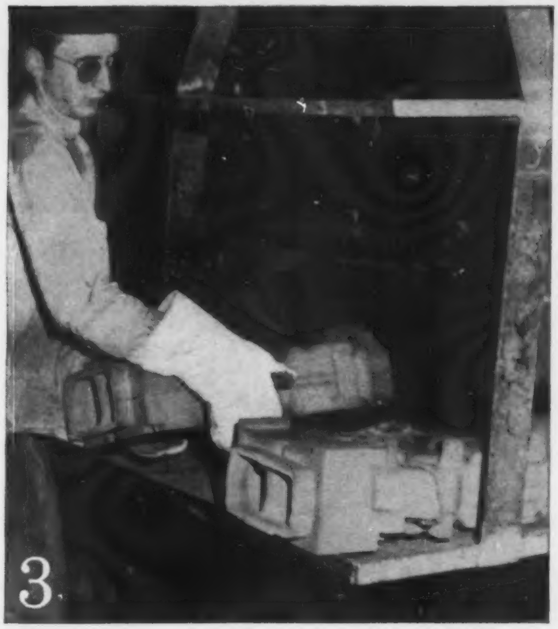
John Deere Reports on Shalco Shell Core Blowing . . .

One piece, completely hollow precision shell cores cut cost of heavy castings

At the John Deere Tractor Works, Waterloo, Iowa, two Shalco U-360 Shell Core Blowing Machines have slashed production costs of large heavy castings for John Deere "New Generation" Tractors. In the photos, follow the production of Shalco one piece, completely hollow precision shell cores. See how they help this famous farm implement manufacturer produce heavy engine block castings . . . faster, more economically. Then, consider this: John Deere's experience is typical. The economical production of large precision cores for heavy duty castings is duck soup for Shalco U-360's. Everywhere, cost-conscious foundrymen are taking advantage of this unique capability and the unmatched service and engineering experience that backs it up. You'll profit by getting complete details. Call, write or wire.



More core production with less manpower —The two Shalco U-360's produce up to 120 precision shell cores per hour (1). With conventional methods, equal output required twice as much manpower! Completed cores are exceptionally strong, but lightweight and easy to handle (2).



Less core processing and handling expense, less cleaning, less material — Shalco one-piece cores have eliminated costly, time-consuming "halving", Result—no core drying, and baking, a reduced requirement for production floor space, less handling, no seam finishing. Shalco cores are amazingly smooth and accurate . . . are completely hollow and at least 33% lighter than solid cores. (To meet John Deere's unusually high specifications, critical areas of these particular cores are sprayed to further assure highest casting quality and strength.)

Last phase of Shalco savings . . . highest quality castings . . . for less — Six Shalco cores (one per engine cylinder) are assembled and the mold is ready for pouring (4). No chance of misalignment here. The Shalco Shell Core Blowing Machines produce identical, precision cores that fit together quickly, easily . . . every time.

Removed from the mold, the rough casting is ready for shakeout (5). Thanks to the excellent collapsability of Shalco Shell Cores, shakeout is complete and there's little need for cleaning.

And here's the completed casting—with sections over 1" thick! (6). Due to the precision and consistency of Shalco Shell Cores, the casting has no sand inclusions. This cuts cleaning time from hours to minutes and greatly reduces finish machining. Less casting stock is wasted, the life of finishing tools is extended . . . and further savings are realized through an additional reduction in manpower.

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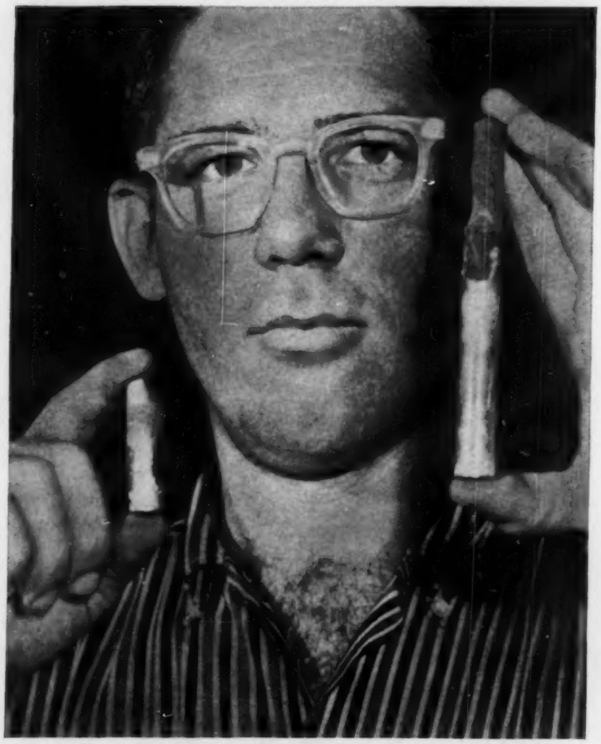
Circle No. 125, Pages 133-134

"Speer's new KOSTKUTTER® RODS save us 20 to 25% over conventional cutting carbons — give us maximum amount of metal removed for every dollar spent on cutting carbons," says Benjamin Desper, Cleaning Room Foreman, Atlantic Steel Castings Co., Chester, Penna.

"Speer's new KOSTKUTTER RODS save us between 18 and 25% over conventional cutting carbons. We like the way they keep the work moving, with a minimum of time spent in changing carbons," says Joseph P. Fucci, General Foreman, Erie Forge & Steel Corp., Erie, Penna.



"Speer's new KOSTKUTTER RODS save us money three important ways — help us get the most out of rods, torches and operators' time," says Floyd Harbin, Cleaning Room Foreman, Commercial Steel Castings Co., Marion, Ohio.

How soon will you join THE SPEER KOSTKUTTER SAVINGS CLUB ?

Join the Speer KOSTKUTTER Savings Club Today! You belong in the "Savingest" company. Use KOSTKUTTER RODS. The reason is plain from these statements — *Savings!* KOSTKUTTERS will produce savings in time and in money. The interlocking feature of KOSTKUTTERS cuts stub loss, keeps torch at work more continuously and prolongs torch life since heat is kept away from the clamp. Become a member of this "Savings Club" soon— dividends are sure and steady.

SPEER Carbon Co. INC.
St. Marys, Pennsylvania

Circle No. 126, Pages 133-134

Metalcasting and Washington

Depreciation Again

Administration is determined to provide industry with tax reform on depreciation rates—and as soon as possible—with early next year as the aim. . . Treasury Secretary Douglas Dillon makes definite promises to this effect, and other Administration spokesmen discuss the necessity of depreciated reform.

Dillon calls for an updating of the Internal Revenue Service calculations of the depreciable "lives" of equipment, so that "they will accurately reflect conditions in this age of rapid technological change," and that "this adjustment calls for a detailed study of the whole range of business experience with all types of equipment."

He adds, "With depreciation procedures improved by basic reform, American business should be in a position to maintain the most modern industrial plant in the world. This should be of great help in avoiding price increases, and thus, in retaining our competitive position in world markets."

Aside from new legislation to reform rates, Treasury has authority to set the "useful life" of equipment, and has begun an industry by industry study with a view to changes. . . It has made a start by reducing the useful life of textile machinery. . . The American Railway Car Institute has urged similar reform for its industry. . . Stating the present "unrealistic depreciation policy has clogged our rails with superannuated jalopies."

In moving now for depreciation rate improvement, the Administration raises speculation as to whether it will ask for legislation along this line next year, giving up its tax measure requested this year, asking that industry be allowed a tax deduction on investment in new equipment. . . This legislation was written by business associations banded together for the purpose, but it was opposed by most industry witnesses who appeared at hearings. . . The proposal was criticized as "a complicated formula," and most witnesses called for "more realistic depreciation allowances which would attack the problem directly."

The group which had brought out the "investment incentive" device obviously sold the Kennedy Administration on the idea —as it had failed to do with the previous Administration—and it is known to still have strong backing in the Ways & Means panel. . . It has worked on and plugged for its proposal for several years, and is far from surrendering.

Whether it is depreciation allowances reform or tax relief on new equipment investment, any changes will result in revenue losses for the federal government. . . This is the big concern —with ever-rising expenditures —that will decide what relief is to be provided.

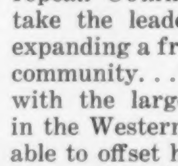
Common Market

Stressing utmost urgency that United States open negotiations for trade partnership with the rapidly developing European Common Market, a report to the Senate-House Joint Economic Committee warns that if all the Western European countries join that market, "as we expect they will, it will then have a much larger home market than the United States, and the implications are only too clear."

The Common Market, which has been likened to a United States of Europe, in that tariff and other trade restrictions are lessened or wiped out, is justifying the most optimistic expectations. . . The report to the Joint Economic Committee, made by former Secretary of State Christian A. Herter (under Eisenhower) and former Under Secretary William L. Clayton (under Truman), points up that since 1958 trade among the Common Market member countries has risen by about 50 per cent—a growth far greater than shown by any other industrial nation. . . When competition forces all such countries to join, the only way the U. S. can hope to hold its export markets is by joining the Common Market.

"We believe," states the report, "that U. S. must form a trade partnership with the European Common Market and take the leadership in further expanding a free world economic community. . . Heretofore U. S., with the largest home market in the Western World, has been able to offset high wages by the mass production of goods, keeping cost on levels competitive with those of other industrial nations. . . The European Common Market already has a home market, in terms of population, as large as that of the U. S. . .

Briefs: The Federal Reserve Board points up indications "that military orders for hard goods have started to flow in really substantial volume within the last several weeks." A Commerce Department survey reveals that manufacturers expect a substantial rise in sales in the closing months of year; and the Department's Business & Defense Services Administration states that metalworking sales this year will hit a new high, well over $150 billion.



By W. R. Fingal

Water District avoids dezincification by going to Ni-Vee bronze

Colorado River water that is used in Southern California is hard on metals – particularly bronzes with high zinc or aluminum contents.

Avoids problem entirely

When they purchased 24 Venturi meters, The Metropolitan Water District of Southern California neatly avoided the whole problem of dezincification by specifying centrifugally-cast Type A Ni-Vee Bronze,* for the throat sections. (See photo above.)

Type A Ni-Vee Bronze, with a zinc content of 2%, is well under the threshold at which dezincification will occur in the Colorado River water. What's more, the composition of Nickel, tin and copper in this alloy makes it highly resistant to corrosion and the effects of velocity. The metal is also responsive to heat treatment to obtain higher than ordinary mechanical properties. In this instance, 85,000 psi tensile strength and 180 Brinell hardness were easily obtained.

5 types of Ni-Vee bronze provide a range of desired properties

Altogether there are 5 basic types of Ni-Vee bronzes, all heat treatable, all with excellent corrosion resistance. Ni-Vee A provides extreme strength; Ni-Vee E provides extreme resistance to galling. The other types have desirable pressure and bearing properties.

For information that will help you specify the best type of Ni-Vee bronze for a particular part, simply write for "Engineering Properties and Applications of Ni-Vee Bronzes."

*Registered trademark

THE INTERNATIONAL NICKEL COMPANY, INC.

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INCO NICKEL

MAKES ALLOYS PERFORM BETTER LONGER

Circle No. 127, Pages 133-134

Around the World with Modern Castings

ENGLAND

Permanent mold casting of aluminum bronze has opened up new markets for nonferrous foundries in England. Automobile manufacturers are the biggest users to date but practically every industry is providing customers, according to Sagar-Richards Ltd. For orders exceeding 500 units permanent mold casting is one of the most competitive methods for shaping this high strength engineering material. Aluminum bronze is one of the best for corrosion resistance and fatigue strength. Die life, always the big drawback to casting these high melting alloys, has been extended to 100,000 castings by using Nimonic—an alloy containing 20% Cr—2% Ti—2% Al—balance Ni. Economy is effected by using this material only as the liner for die. It is backed up with cast iron. Casting sizes range from fractions of an ounce up to 40 pounds and walls as thin as $\frac{3}{32}$ of an inch.

SWITZERLAND

One of the World's foremost sand technologists, Dr. Franz Hofmann, head of the sand research department of George Fischer, Ltd., has just completed an extensive study of the effects of molten metal on moisture in sand molds. Mold surface defects such as crust separation, rat tails and scabs will be better understood as the result of this work. For molds with risers located directly over the mold cavity, steam escapes readily through this opening. But with side risered molds, steam generated on the cope surface is diluted and swept through the compacted sand by the super heated and expanding air of the mold cavity displaced by the rising molten metal. The complete scope of this work will be unveiled at the International Foundry Congress in May at Detroit.

AUSTRIA

A continuous casting plant automatically produces from molten metal cylindrical rods measuring 0.8-2.8 inches in diameter. Copper-base, aluminum-base, and gray iron chips or scrap can be melted and cast continuously in a water cooled mold. The rod is also machined as it feeds from the casting machine and is cut into standard lengths. Casting rate ranges from 110-140 pounds per hour per machine.

HUNGARY

The use of pure magnesium for nodulizing ductile iron is preferred in Hungary because heat losses are a lot lower than when alloys are added. Ladles have been designed with motors that feed magnesium rod into the bottom of the ladle thus assuring complete immersion beneath all the metal being treated. High recovery of magnesium is further improved by equipping ladles with hermetically sealed lids that permit six atmospheres pressure to be maintained on the melt. An alternate method involves

(Continued on page 14)

(Continued from page 13)

injection of magnesium into the melt through a tube using CO_2 pressure. This practice is rather similar to the technique used at Jamestown Malleable Iron Co. and described in this issue of MODERN CASTINGS.

RUSSIA

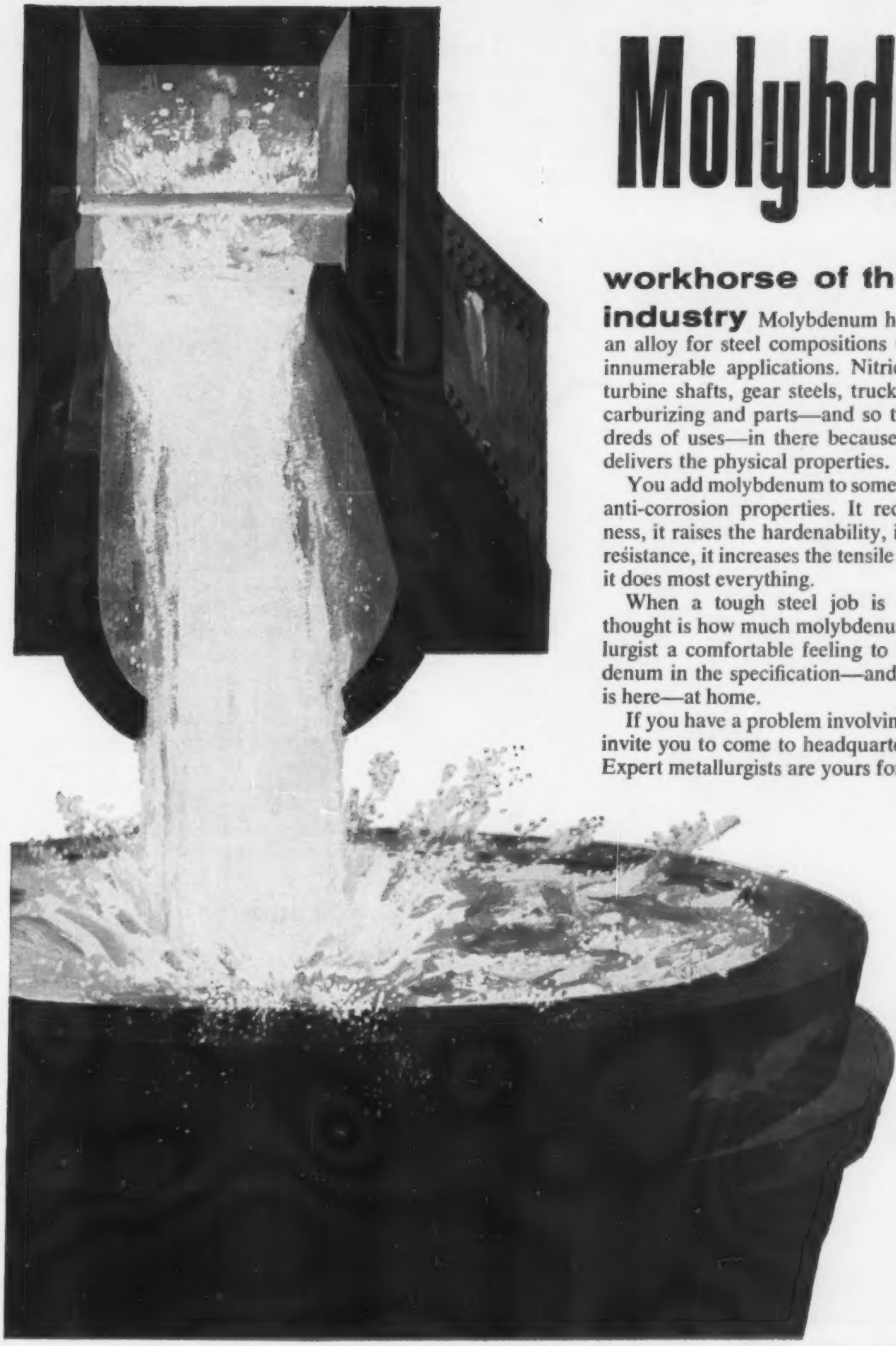
Electromagnetic pumps are used for mechanizing and automating the handling of molten iron and non-ferrous metals. An outgrowth of atomic-reactor technology where molten sodium is circulated by pumping, the motive forces are produced by interaction of magnetic fields and electric current passed through the molten metal.

Metal flow rate through a ceramic conveyor tube can be controlled by adjusting electrical current. Reversing the magnetic field will stop metal flow. One installation is designed to move molten gray iron from the cupola to a moving line of molds on a conveyor. Pouring will also be effected by an induction pump. Another system feeds molten brass into a die casting machine.

Aluminum can also be transported by electromagnetic pumping. By using "plumbing" to deliver molten metal, much of the batch type movements in ladles by crane, truck, or trolley can be eliminated. As the technical bugs are worked out of this new concept in materials handling, molten metal movements should be greatly simplified.

FRANCE

M. Tetart, Regional Director of Messier, leading French producer of aircraft components, returned from a tour of United States magnesium castings facilities and announced that Messier will use the new techniques developed in the U. S. in exchange for some of the Messier processes used in metalcasting. Their processes produce 20 per cent more net weight of castings from the same volume of molten metal. As early as 1955 Messier had replaced forgings in their landing gears for French supersonic jet aircraft with highly advanced light metal castings produced in their Pyrenees Plant foundry. M. Tetart expressed the opinion that "We in France have concentrated on progressively improving the mechanical properties, corrosion resistance, and insuring predictable structures, product uniformity and service life of magnesium castings. This is because magnesium is the lightest metal at acceptable cost, and because casting developments alone among the basic metals processing and fabricating processes have been most neglected and offer greatest potential. The extension of unique and unprecedented U. S. casting development on Government projects is considered pregnant with promise and appears long deferred in application by U. S. Military and Industry."



From and For the Reader . . .

MORE ON ORDNANCE

In regard to the article on ordnance in the November issue of MODERN CASTINGS. We find the following improvements in the casting method would lead to the use of more castings:

(1) Microporosity minimization or elimination. Microporosity is represented by an area of small voids usually caused by solidification shrinkage. The pattern of solidification, is, in turn, a function of gating, risering, and chilling. Therefore, any improvement in the area of solidification either by improving existing gating and risering techniques and/or by any other means will result in minimizing or eliminating these voids.

(2) Microsegregation control. Microsegregation is represented by chemical inhomogeneity which occurs as a consequence of the dendritic solidification pattern and the phase relations of the alloying elements. It has been determined that this microsegregation is detrimental to the mechanical properties of steel. Therefore, any methods developed to control microsegregation during solidification will lead to the use of more castings.

(3) Improvements in mold design. Mold manufacturing improvements would also assist in increasing the employment of more castings. The development of a mold that maintains dimensional stability, that does not interact with the molten metal and that lends itself to modification so that solidification can be controlled within the mold would be a solution to existing mold problems.

The preference of castings over components fabricated by competing methods is, of course, dependent on a number of factors.

Economics will often be in favor of the casting method, for theoretically it is the shortest processing procedure between the state of molten metal and a useful shape. Castings are often preferred because they lend themselves to intricate design. Unquestionably, casting components is the most economic and expeditious method

(Continued on page 18)

LETTERS

(Continued from page 16)

of producing complex shapes providing quality, strength and reliability can be assured.

S. VALENCIA
Watertown Arsenal Laboratories
Watertown, Mass.

DUCTILE IRON CLASSIFICATION

There is certainly a need for a universal terminology covering the different forms of graphite found in ductile iron and an agreement on the causes of these various forms, as well as their effects on properties such as "Ductile Iron Form Classification" by C. K. Donoho on page 65 of the July MODERN CASTINGS. We believe that Type V of Fig. 3 should be included in any classification system. This type is usually found associated with the graphite-rich layer resulting from the flotation of carbon.

The inference can be drawn that the higher than normal ductility for the sample shown in Fig. 6 is due to the small nodule diameter. This may be true, but we do not believe that one example justifies such an implication, if it is intended.

It has been our practice to determine the number of nodules per sq. mm. rather than rate the nodules by size. However, there is an approximate relationship between size and nodule count. We understand that each nodule represents a nucleation center or eutectic cell during solidification. We have found lower nodule counts, and thus larger graphite nodules, in heavier section castings than in light section castings. This would be expected on the basis that slower cooling rates usually result in fewer centers of nucleation. There are other factors, such as degree of superheating and degree of undercooling, which could affect nucleation. We wonder if something might not be said about this relationship of nodule size to nucleation, if you agree that this relationship does exist.

There is an error in Table 1, page 69, under "As-Cast Tensile Properties." Both "T.S. x 10^{-3}" and "Y.S. x 10^{-3}" should be "T.S. x 10^{3}" and "Y.S. x 10^{3}."

We take exception to the statement on page 69 that normal as-cast

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IF IT'S A "POP-OFF" . . . IT'S HINES . . . IF IT'S HINES . . . IT'S THE BEST

Circle No. 133, Pages 133-134

(Continued from page 18)

ductile iron with all Type I graphite will have the average properties shown. This may be true with the particular composition range employed in your foundry. We do not believe that composition can be ignored or minimized in any discussion which deals with properties. We think it would be desirable to show the composition for each of the test bars listed in Table 1, as well as the composition target range for your iron.

We wonder if some readers might not take exception to the statement "that 80-60-03 requirements can be met with up to 40 per cent vermicular, or Type III, graphite." This is true, of course, when the composition is such that the properties of the iron would have had the "average" properties that you show. Unfortunately, however, specifications are based upon minimum values, not averages, and the discerning reader might well inquire what properties would be obtained if the properties without vermicular graphite were near the minimum of the specification. We believe the point—that vermicular graphite is not as damaging as one would think—could be made without reference to the specification.

We have not encountered the graphite form designated as "L" in German classification or Type II in your paper, at least not quite as irregular in shape as shown on the charts. We quite often find imperfectly shaped nodules and, in fact, the perfect spheroids, as shown as *K* or *I*, are observed less frequently than the slightly imperfectly shaped nodules. We accept these imperfectly shaped nodules as normal and, as far as we know, these have no adverse effect on properties, at least we have not been able to relate the degree of spheroidicity to properties. We were wondering whether or not *L* and "II" are not somewhat exaggerated.

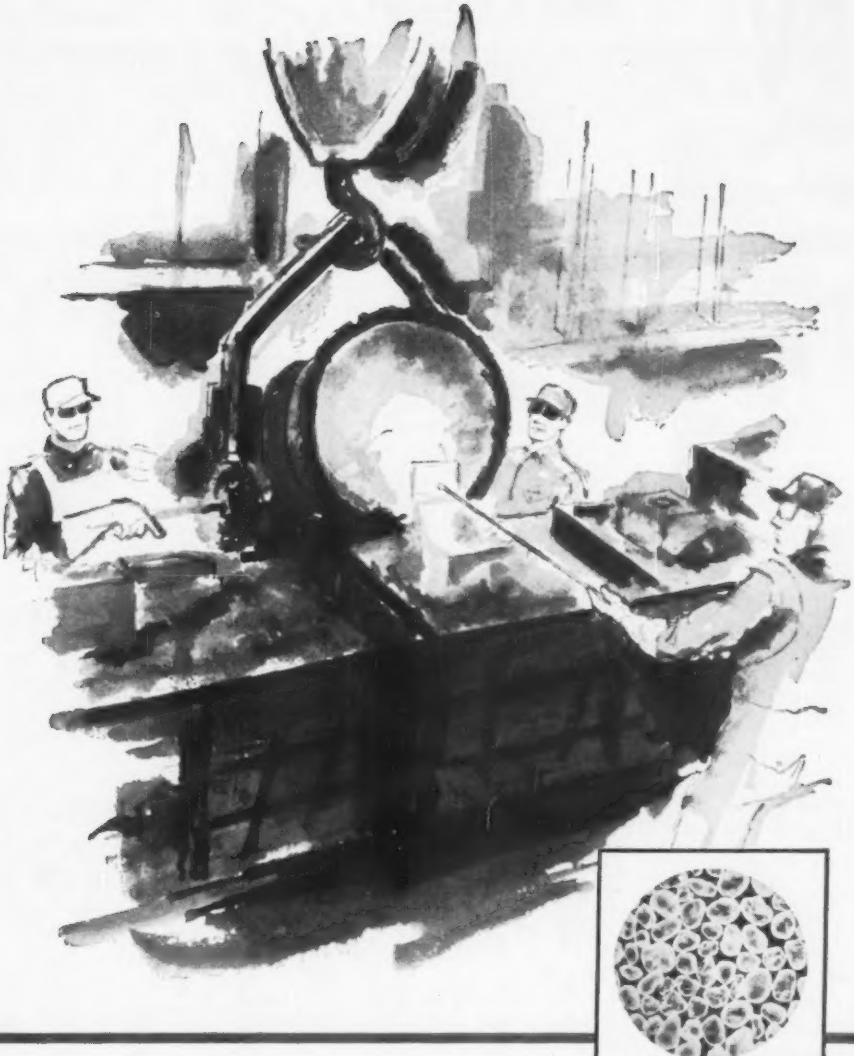
A. H. RAUCH
Materials Engineering Dept.
Deere & Co.
Moline, Ill.

Author's Reply: In general, your comments are quite pertinent, and we do not find much to argue about. However, we must disagree with you regarding our captions for Table 1, where we use T.S. x 10^{-3} and Y.S. x 10^{-3}. Of course, we both know that the first figure 81.6 means 81,600 psi. This could be expressed in the Table as 81.6 x 10^{3} psi. However, in the caption T.S. x 10^{-3} expresses exactly what this figure, 81.6, is; that is, it is tensile strength in psi multiplied by 10^{-3}. We have been through this many times, and I believe a little reflection on your part will show that we are mathematically correct.

With regard to the assumed average properties of 90-65-12 for as-cast ductile iron, we checked this rather carefully for our as-cast ductile iron for fittings, and these are reasonably average keel block properties when the graphite is predominantly spherulitic. Of course, we get some lower values when the graphite form is not optimum, but we also get some better values with up to 22 per cent elongation, although of course, at somewhat lower strength levels.

We agree that composition cannot be ignored in dealing with properties. However, we did not wish to complicate our discussion of structure with factors that are generally quite well understood. After all, we are not attempting to give a comprehensive text book on ductile iron in this paper.

C. K. DONOHO



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Circle No. 135, Pages 133-134

TRENDS IN EDUCATION

Apprentice Program Pays Off at Howard Foundry

By R. E. BETTERLEY

What is happening in foundry apprenticeship training today? This question was thoroughly discussed at the Second Biennial North Central States Apprenticeship Conference held in Chicago October 26 and 27. Over 750 leaders from labor, management, education and government attended.

This writer participated in the foundry sectional meetings held on both days. Realizing that many foundry apprenticeship programs have been dropped or reduced to token efforts, it was refreshing to learn of the highly successful program at Howard Foundry in Chicago. This program was discussed under the topic: "Starting and Operating a Successful Apprenticeship Program in the Foundry," by Ben L. Weissman, Director of Industrial Relations, Howard Foundry, and Clarence Clinkscales, Financial Secretary, International Molders and Foundry Workers, Local No. 233, Chicago.

The Howard program was initiated in 1946 when it was realized the long-range plans of the company should include training to an ample supply of skilled personnel. Commenting on the success of the program, Mr. Weissman said, "In spite of early problems, that apprentice training program is still in operation today. Over the years it has made a good contribution to our manpower needs." He further stated, "The program averages about 15 apprentices per year and 255 journeymen have been trained during this time."

The program is handled by a joint apprenticeship and training committee representing labor, management and education. Assistance is provided also from the U. S. Dept. of Labor Bureau of Apprenticeship and Training. The basic philosophy is built on the following points:

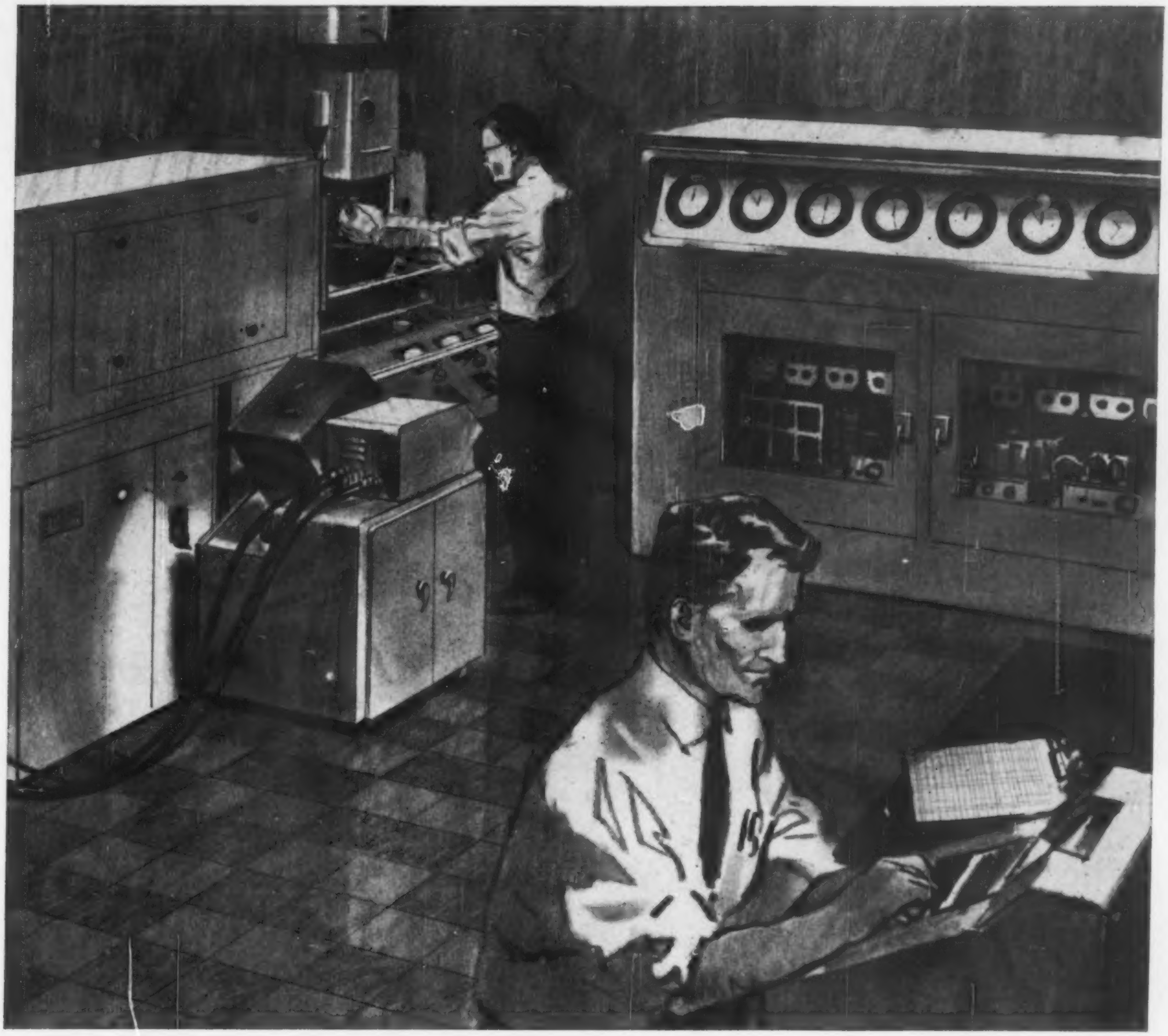
- Program scheduled according to selected training standards.
- *Training* not to be a "bargaining" point between labor and management.
- Recruitment not limited to the young High School graduate—in fact, the older but capable apprentice is sought because of maturity, draft status and family responsibilities.
- Scheduled training *must* encompass all important areas, i.e. coremaking, molding, patternmaking, etc.
- Apprentice should *select* objective or area early in the program.
- Trade schools to help provide related instruction.
- Specific plant duties taught by qualified plant personnel. (Recent journeyman graduates have proven to be the best instructors because of their understanding of the needs and problems of the new apprentice.)
- Apprentice should have opportunity to openly express himself in joint meetings with leaders.

Participants have been accepted from all walks of life. However, three major sources stand out: (1) The union which maintains a file of interested candidates, (2) the plant's own semi-skilled work force, and (3) trade schools and technical high schools. To me, it was significant that frequently experienced journeymen in the foundry suggest their own sons.

Mr. Weissman indicated the following as qualifications and considerations in candidate selection: (1) High school graduate preferred, (2) mechanical aptitude (determined after 6-month orientation period), (3) a genuine interest in the work and training program, (4) willingness to apply ability, (5) promptness and good attendance, (6) personal character, and (7) ability to listen and accept instruction.

Representing Labor, Mr. Clinkscales also praised the success of the program as resulting from a joint effort of labor and management. He said, " . . . in the past 15 years, 30 foremen and 15 superintendents have been upgraded from this apprentice course."

Birth of a Gray Iron Casting—No. 5



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Quality controls exercised in the selection of ores and coals and carried into every step of production are the main reasons why Neville Pig Iron and Neville Foundry Coke have earned the highest reputation in the foundry industry.

Just recently a Research-Direct Reader Spectrograph was placed into operation. This instrument provides both production and quality control over the constituent elements in raw materials, assuring maximum quality in all grades of Neville Pig Iron.

In like manner, every carload of Neville Foundry Coke has been sampled and tested in our modern laboratories during production and prior to shipment. With this procedure Pittsburgh maintains the high standards of physical properties and chemical analysis so essential in the production of quality by-product foundry coke.

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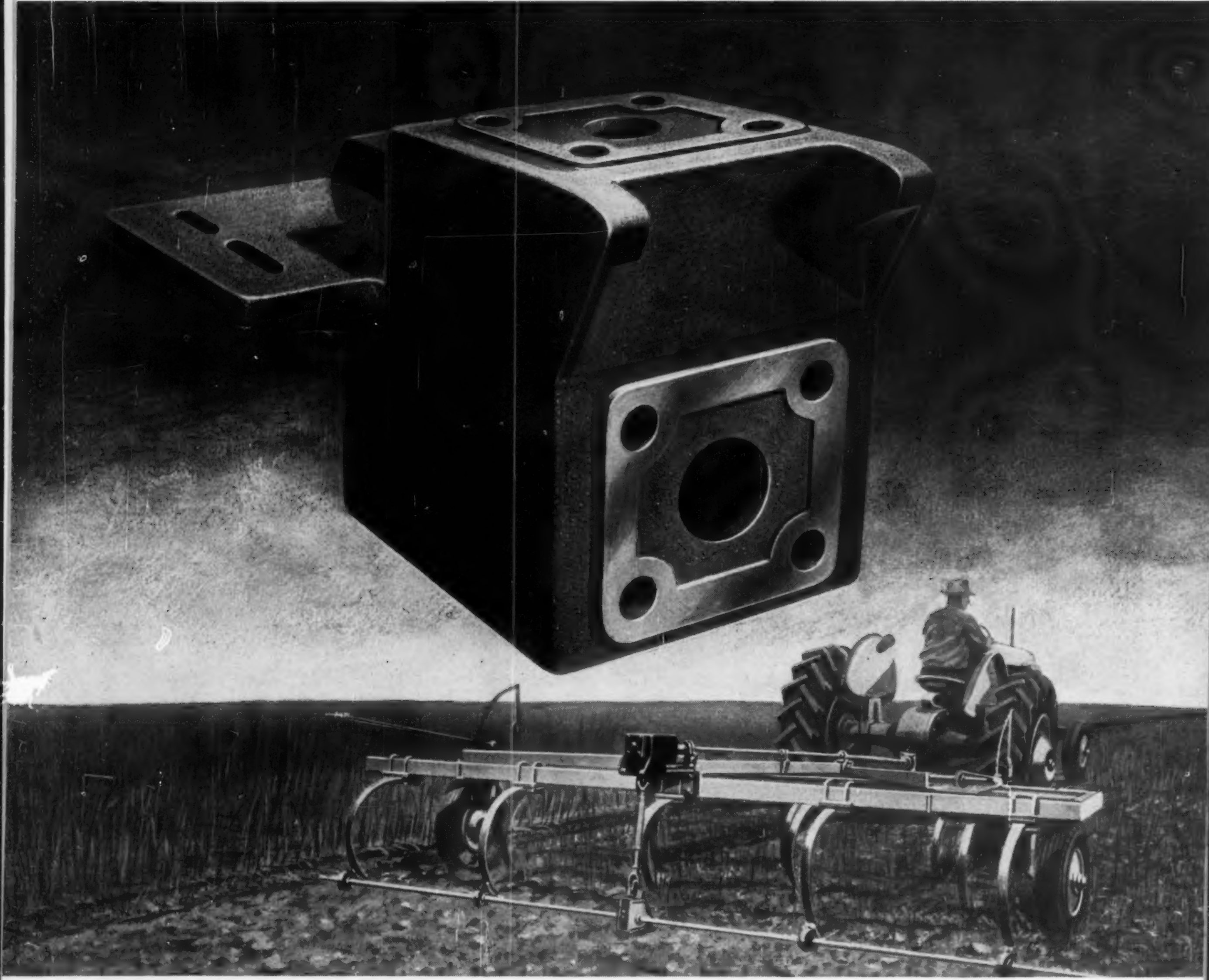
Neville Pig Iron and Neville Coke for the Foundry Trade

Circle No. 137, Pages 133-134

How the Foundry Industry Serves America . . . #15 of a Series



CAST IRON MITER GEAR BOX REPLACES WELDMENT, LOWERS UNIT COST 54.9%

Working off the tractor power take-off, this cast iron miter gear box operates a rod weeder that pulls out weeds as the field is plowed. Formerly a weldment, the gear box then required seven machining and fabricating operations, cost $25.32 to make. Now, as a gray iron casting, it's produced for just $11.40! Included in the cost is the cast iron cover which doubles as an identification nameplate for the equipment.

Besides lowering unit cost 54.9 per cent, the conversion from a weldment to a gray iron casting brought about improved product appearance, and increased production with less manufacturing equipment. The excellent dampening characteristics and resistance to distortion of the iron casting preserve close tolerance of oil seals and reduce lubricant leakage.

This is one more example of how versatile, modern iron castings can reduce manufacturing costs and solve many of the complicated problems of industrial design.

For the production of structurally sound iron castings, Hanna Furnace provides foundries with all regular grades of pig iron . . . foundry, malleable, Bessemer, intermediate low phosphorus and Hanna Silvery.

Facts from files of Gray Iron Founders' Society, Inc.

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Circle No. 138, Pages 133-134

Three Explosions—Three Dead

By Herbert J. Weber

Recently three serious explosions have come to my attention. They are reported here as a warning to other metalcasters.

Case 1. The foundry had operated a water-cooled cupola continuously for a week. It was then decided to determine if there had been any erosion of the bottom bed.

The cupola was shut down and tapped. The prop was pulled but the bottom failed to drop. The cupola was repeatedly jarred with the charging arrangement to loosen the bridging but without success.

Fearing a freeze-up, a supervisor ordered water hosed into the charging door hoping the steam pressure would force the bottom.

After 15 minutes of this treatment, the cupola blew up. One man was killed and several others were so severely burned that physicians did not believe they would recover. (Fortunately they did, but with permanent scars.)

This company had a 100 per cent eye-protection program or one of the survivors would have lost his eyesight. His face, head and safety goggles were spattered with molten slag and metal.

So severe was the explosion that the cupola was raised off its foundation and the cap blown about 100 feet in the air.

Case 2. This foundry was making a large casting. Because of the complex design and rigid quality requirements, special methods are used to achieve solidification.

Two cooling vanes are inserted into the cores in order to extract heat at an accelerated rate. Air and small amounts of atomized water are passed through the vanes.

Because of the possibility of explosion, hydrostatic pressure tests of the system were always made prior to pouring.

The error which initiated the accident apparently was a technician's failure to connect the air-atomized-water hose to the supply line.

It is believed the copper tubing and aluminum fins melted and the residual water in the system came in direct contact with molten metal.

The explosion was so severe, that two men died of their injuries. A third man is expected to survive.

Case 3. A crucible of molten aluminum was too full for pouring. One of the men picked up a ladle hanging on a wall to remove some of the metal.

The ladle was barely introduced into the melt—not more than ½ in.—when a violent explosion occurred.

Pieces of the cemented carbide crucible were blown 15 feet away and the ladle man's shoulders, chest and arms were splashed with molten metal.

It is my own opinion that there was a thermit reaction between molten aluminum and iron oxide.

Molten aluminum will not attack clean iron but will react with explosive violence with oxides of metals.

Actually its reaction with water is thermit but the expansion of water volume is also involved. An ounce of water will expand to a steam volume of more than 30 gallons.

Any molten metal on the following list will theoretically react with the oxide of the element below it with increasing energy as the spread increases.

1. Beryllium
2. Magnesium
3. Aluminum
4. Zirconium
5. Titanium
6. Silicon
7. Boron
8. Sodium
9. Zinc
10. Tin
11. Iron
12. Hydrogen
13. Lead
14. Bismuth
15. Copper
16. Nickel

The spread between aluminum and iron oxide is great.

It is hydrogen and iron that give us the greatest concern, because in aluminum foundry practice, it is the oxides of hydrogen (water) and iron that are present.

Iron is particularly dangerous because unnoticed rust or scale may be present on a tool or ladle. All iron or steel furnace tools must be kept free of oxide scales.

The unfortunate experience of these three foundries should be a lesson to us. But will it?

New Books...

Refractories Product Index

Product Directory of the Refractories Industry in the United States. New directory lists 3548 different brands of refractories for the lining of industrial furnaces. This is an increase of 24 per cent over the previous edition published in 1958. The 224 page directory is a single source to who makes what and where in the refractories industry giving a company-by-company breakdown of products. The 170 companies listed represent almost 100 per cent of the over $400 million dollar annual sales volume of the industry.

Special sections are devoted to manufacturer's names and addresses, plant locations by state and city, product divisions, a complete list of brand or trade names.

Revision of Fire Codes

National Fire Codes . . . 7 volumes, 186 separate standards, 5846 pages. This is a new and revised edition incorporating 48 fire protection standards adopted this year by the National Fire Protection Association plus 138 other current NFPA standards.

Material is divided into seven major categories covering flammable liquids and gases; combustible solids, dusts, chemicals, and explosives; building construction and equipment; fixed extinguishing equipment; electrical; transportation; and mobile fire equipment, organization, and management. The standards and codes are drawn as recommendations for safety to life and property from fire without causing unnecessary inconvenience or expense.

Analysis of Casting Defects

Fehlererscheinungen An Gussstrucken (Defects in Castings), E. Knipp, 301 pages. Published in Germany, the book cites 340 references from almost 200 different authors. All defects, including surface and internal, are discussed. Means are given for preventing the defects as much as possible. The causes that underlie defects are thoroughly explained and many charts and tables are presented that supplement the text. The greatest part of the book deals with defects in iron and steel; 60 pages are given to non-ferrous metals.

Techniques for Improving Engineering Operations

Engineering Management and Administration . . . 441 pages. Val Cronstedt. Covers policies, practices, and techniques for every phase of administration in an engineering department. Includes such areas as patent law, safeguarding industrial secrets, financial controls, personnel matters, compensation administration, and others. Presented from the viewpoint of the engineer charged with management responsibilities.

Shear and Torsion Standards

Symposium on Shear and Torsion Testing . . . 120 pages. A comprehensive review of shear and torsion test methods and information useful in establishing recommended shear and torsion test practices. Published by the American Society for Testing and Materials.

Industry Acceptance Helps Expand T&RI Program

Increased chapter participation and support by metalcasters brings most successful year. Emphasis continues on regional courses with expansion of curriculum.

AN EXPANDED AFS Training & Research Institute program has been slated for 1962 as the most active and successful year in the Institute's history nears completion.

Well over 2000 foundrymen-students took part in the five-year program with more than 500 participating in the 1961 schedule alone. Based on the 1961 experience, two factors stand out:

(1) The excellent response and interest in regional courses co-sponsored with AFS Chapters.

(2) The increasing attenddance.

In 1961, five courses were given on a regional basis—Houston, Texas; Birmingham, Ala.; Hamilton, Ont.; and two at Chattanooga, Tenn. An average of 46 students per course attended.

In explaining why the co-sponsored courses have such a drawing power, T&RI Training Supervisor R. E. Betterley said:

"In co-sponsored courses, chapters do a fine job of promoting because the T&RI course is a part of their educational program. They make an all-out effort to get their members to realize the value in course attendance. The chapter response has been gratifying."

Asked the reason for more consistent attendance at the courses, a leveling-out of the enrollment, Betterley stated:

"We have learned from surveys and those attending what courses are preferred and where training is needed by the industry. Maximum course participation this year means continuation of all courses, and several new subjects have been added."

Betterley emphasized that course co-sponsorship with chapters should be maintained at the present rate or accelerated. He stressed that the present role of the T&RI educational program with its regional courses would not be affected by the building of the proposed Training Center Building to adjoin the present National Office in Des Plaines, Ill. "They are, and will continue to be an integral part of the complete program, continuing to serve the AFS Chapters and the industry throughout the country," commented Betterley.

U. S. Is Too Casual

The AFS Director of Education agreed with the philosophy of Jan Verschoor, director of overseas operations for the Raadgevend Bureau of B. W. Berenschot Co. of Holland and its American subsidiary in White Plains, N. Y., who declared:

"U. S. industry is either too casual about employee training or confuses it with general educational efforts that have no immediate effect on worker and productivity. This general education approach provides a long-term base, but far too little is being done to fill the specific needs for skills right now.

"Accelerated skill training, on the other hand, is aimed at solving an immediate problem by providing training for personnel to perform a specific job in a specific plant or facility in order to produce a specific product or service. Thus, in contrast to a general educational approach such as an apprentice program, the accelerated training is a direct solution to problems brought about by accelerated changes that have occurred and will continue to take place.

If regional programs have been so successful, why consider presenting the courses at a central building, is one observation.

Two reasons are advanced. One is that the proposed Training Center Building will allow presentation of courses with emphasis on the how-to-do techniques. With proper facilities, additional teaching methods and demonstrations can be utilized to the maximum. Much of the training program to date has been lectures. "Specific techniques are best taught when combined with live demonstrations and student participation. This significantly broadens the scope of courses that could be

offered—leading eventually into course sequences directed toward specific goals," said Betterley.

A second reason offered is that a diversified program of courses will draw students from a large area. Nearly 90 per cent of those attending non-regional courses came from beyond a 50-mile radius. Courses have been given in Chicago, Detroit, and Milwaukee, however, 15 states have registered more than 15 foundrymen in the program. These include Illinois, Wisconsin, Michigan, Ohio, Indiana, New York, Pennsylvania, Alabama, California, Tennessee, Missouri, Minnesota, Massachusetts, Texas, and New Jersey.

Geographically, students have come from 38 states, ranging from California to Massachusetts, and from Minnesota to Florida. In addition, enrollees have been drawn from four Canadian provinces, Mexico, South America, Asia, and Europe.

Industry Supports Program

Industry support of the program is shown not only by an increasing attendance—more than 500 in 1961 compared to 358 in 1960—but also by the rising number of repeating companies. Over 700 companies have taken part. More than half of the 1961 T&RI students came from companies having sent men previously.

Continued expansion of the program is advocated by the T&RI Trustees:

"The Trustees of the AFS Training & Research Institute believe that greatly increased demands for qualified personnel will be made by all industry and that the need for broader training of all occupational groups will steadily increase."

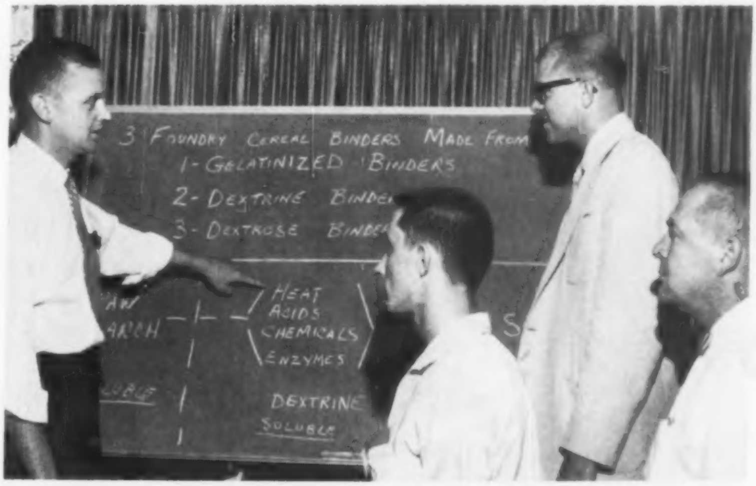
Reactions to the T&RI program are indicated by many comments by students. These are typical of how various courses were evaluated:

"I have the privilege of attending several of your cupola sessions and was sincerely impressed with the very capable and efficient manner in which it was handled. I believe you are doing a very worthwhile job and feel that these courses are fulfilling a critical need in the foundry industry. I am sure that the time and money spent attending these sessions will be repaid to us many times over, and I sincerely recommend that our member companies exert every effort to subscribe and support these courses and thus assure their continuance for many years."

"I was especially impressed with the caliber of the instructors and the outlines which they had to follow. A course of this nature, in my opinion, must be well oragnized in order to cover the many facets of the subject. This was done in good style and sound choice certainly made of the men who presented the information in each of the areas."

"This is the second year that I have sent some of my people to T&RI courses and I am pleased to report that the results are highly favorable as I view them."

"The efforts of the AFS in promoting this much needed preventive maintenance program in our industry are appreciated and I am sure this initial venture will prove beneficial to all of those attending."



Laboratory courses with emphasis on how-to-do-it (pictured above) have been well received. A Training Center building would help to increase this type of instruction. Regional courses continue to offer on-location opportunities.

SILICON CONTROL IS IMPORTANT TO YOU, TOO!
Globe Silvery Iron gives you positive silicon control. By using Globe Silvery you avoid the need for highly concentrated alloy additions.
You benefit because Globe Silvery is virgin metal produced in a blast furnace from natural iron ores. Tramp elements are consequently at a minimum.
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New Injection Process Modifies Malleable—Produces Ductile

Jamestown Malleable is making ductile and malleable castings with unique processes involving injection of pure magnesium into molten iron. Company officials point to malleable section sizes as heavy as five inches. They describe the savings in heat treatment time as "phenomenal."

TWO NEW PROCESSES now make it possible to use a single base iron to produce ductile, malleable and magnesium modified malleable iron castings.

The new processes, both involving the injection of pure magnesium into molten iron, were developed at Jamestown Malleable Iron Division of Blackstone Corp., Jamestown, N. Y. With them, the company has successfully entered the ductile iron field and at the same time significantly improved its malleable iron position.

Harry B. Laudenslager, Jr., Director of Research and Development for Blackstone Corporation, and Everett W. Hale, Chief Metallurgist for the Division, are the two men instrumental in the development of the new methods.

Since the company is primarily a malleable iron foundry, they were faced in the desire to produce ductile, with the disadvantage of using remelt when nickel, copper or silicon is alloyed with magnesium. Conscious of the many applications open to ductile iron, they decided to embark on the manufacture of both types of metal castings.

Facilities of Jamestown Malleable, which has a capacity of about 12,000 tons of iron castings yearly, include a laboratory for chemical and engineering property control (including X-ray and Cobalt 60), a pattern shop, continuous molding, shell molding, hydraulic presses for sizing, straightening and coining operations, and punch presses for sizing, shearing and punching.

The charge going into the cupola consists of 50 to 60 per cent scrap and remelt material, 35 to 45 per cent steel scrap and the balance about 5 per cent silvery pig.

All of these materials are low in sulfur so the iron coming from the cupola contains only 0.07-0.08 per cent sulfur. As the iron runs from the cupola to the air furnace it is automatically treated with soda-ash to further reduce the sulfur content to 0.04-0.05 per cent.

The air furnace is used as a large forehearth or holding furnace where the carbon is further reduced and the temperatures adjusted to meet pouring requirements. This large bath of metal provides a constant supply of consistent quality base iron for making ductile iron, malleable iron and modified malleable.

The air furnace metal analyzes about 2.20-2.40 per cent carbon and 1.40-1.50 per cent silicon. By ladle modification they can produce an almost unlimited variety of irons to meet specific customer needs.

To Make Ductile

In the case of ductile iron, carbon is brought up to a minimum level of 3.00 per cent by placing carbon or graphite in the bottom of the ladle and tapping the air furnace metal on to it. Ladles from 400 lb. capacity up are used as long as the height of the metal is twice the diameter.

Economics are affected by the natural laws where volume and temperature vary, the same as when any alloy is employed.

Even though the sulphur content of the metal coming out of the air furnace is down in the 0.04-0.05 per cent range, further removal is effected by injecting calcium carbide. Every point of sulphur removed means that much better recovery of magnesium in the treatment that follows. Hale

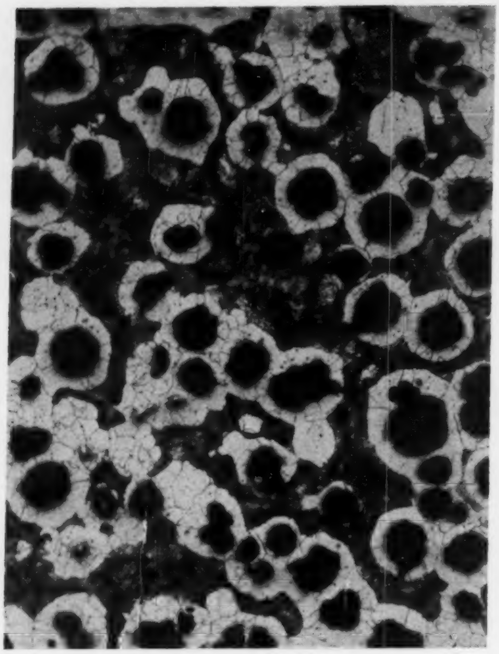


Figure 1—As cast ductile iron (100 x magnification)—3.74% C, 3.01% Si, 0.28% Mn, trace S, 0.045% P, and 0.049% Mg.

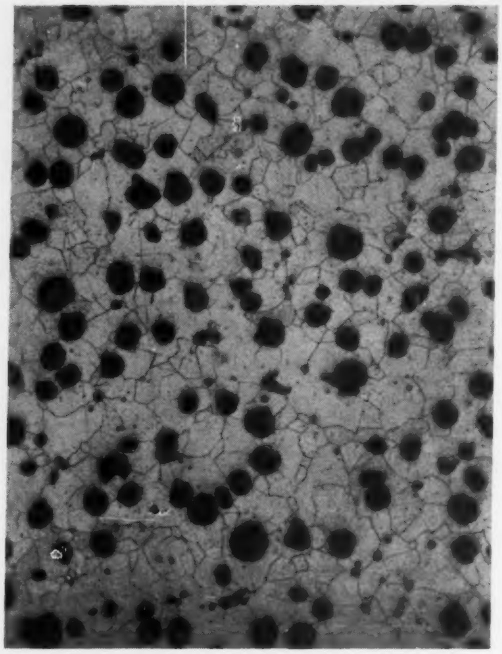


Figure 2—Fully ferritic ductile annealed (100 x)—3.74% C, 3.02% Si, 0.28% Mn, trace S, 0.049% Mg, 0.04% P.

explained that one of the most unusual features of the process involves the magnesium treatment. Pure atomized magnesium spheroids ranging in size from six to 100 mesh are injected into the melt with nitrogen. To accomplish this trick a carbon tube (2 in. O.D. by ½ in. I.D.) is lowered into the bath and the nitrogen-magnesium injection effected. Immediately following magnesium treatment sufficient quantity of 85 per cent ferrosilicon is dumped into the ladle to bring metal content up to 2.75-2.80 per cent silicon. By continuing to agitate the melt with nitrogen gas, the silicon is thoroughly mixed into the melt. This practice has the added benefit of eliminating any need for reladling of metal and consequent metal temperature loss.

The company has made ductile iron continuously since August 1959 through the use of this method, producing as high as 30 tons a day in relatively small castings.

Malleable Improved

The adaptation of magnesium injection to Jamestown Malleable's production of malleable iron is a significant step in malleable production. Less than 0.04 per cent magnesium has worked wonders in malleable iron. Casting section sizes as heavy as five inches are now feasible, and properties of both ferritic and pearlitic malleable are extended.

The savings in heat treatment time are phenomenal. Where it is common practice to hold for 8 hours at 1700°F. for first stage graphitization, now it can be accomplished in two or three hours at 1600°F. As for second stage annealing, the modified malleable requires only 3 to 4 hours at 1300°F. compared with 17 hours of slow cooling from 1450°F. to to 1250°F.

A. E. Schobeck, President and General Manager of Jamestown Malleable, points with pride to the 500-pound gear blanks that they are casting with a rim measuring 5 by 3 inches in cross section. Normal malleable would be mottled in such heavy section and flake graphite would destroy tensile properties.

Tensile properties are retained in heavy sections in modified malleable because any premature graphite formation is micro in its nature and does not impair the physicals.

Impressive Properties

Physical properties of the modified malleable are indeed impressive. The ferritic grade develops an ultimate tensile of 62-66,000 psi, a yield of 47-50,000 psi, an elongation in 2 inches of 18-23 per cent in standard ⅝ unmachined test bar.

There is no retained pearlite or picture frame sometimes present in standard malleable. After annealing, the structure consists of ferrite and graphite.

Pearlitic grades offer maximum 140,000 psi, tensile, 110,000 yield and 2 per cent elongation.

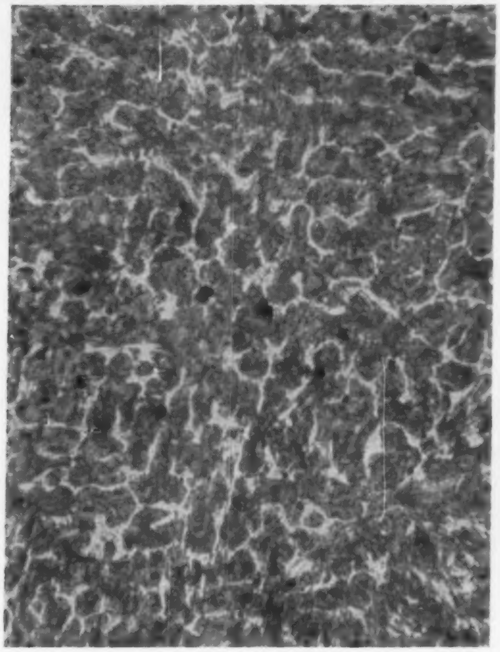


Figure 3—Modified malleable 1-in. section as cast (100 x)—2.24% C, 2.22% Si, 0.28% Mn, trace S, 0.028% Mg, and 0.045% P.

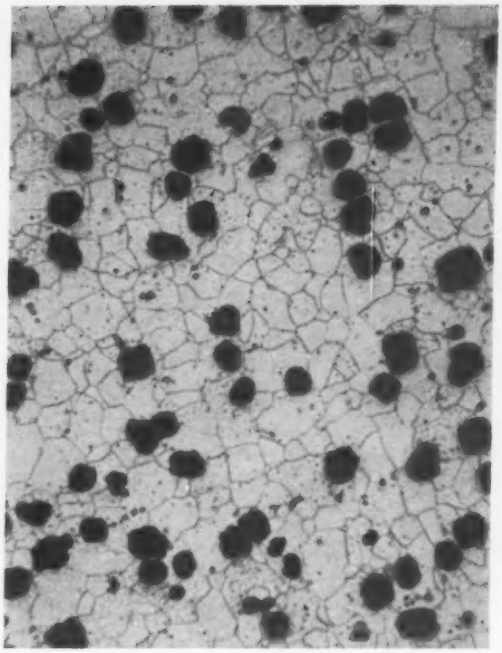


Figure 4—Fully ferritized modified malleable (100 x)—1-in. section. 2.24% C, 2.22% Si, 0.28% Mn, trace S, 0.028% Mg, 0.045% P.

The basic method for producing modified or improved malleable iron starts out with the normal white iron chemistry—no deleterious elements such as tellurium, bismuth, boron, nickel, lead, copper or chrome are permitted.

If desired, a slight increase in silicon can be made prior to the magnesium injection. The amount of silicon added ranges from 0.5 per cent to 1 per cent. This serves to increase fluidity and may accelerate graphitization in the anneal.

The metal is now ready to pour without reladling. Heat treatment is then required to convert the iron carbide structure over to ferrite and temper carbon.

Many Advantages

Some of the advantages of adding pure magnesium to improve malleable iron are:

1. Residual magnesium in white iron enables the producer to rearrange carbon and silicon as desired without precipitation of flake graphite.

2. Yield strength can be raised or lowered at will; increasing silicon will raise the yield strength and lowering it will lower the strength. This can be an important factor in cold working.

3. Silicons as high as 2.50% do not impair the impact properties and with low carbon iron, impact values may increase at room temperature.

4. Carbides break down easily at 1600°F. First stage graphitization can be accomplished in from two to five hours. Complete ferritizing can be obtained with annealing cycles of 10 hours or less.

5. In modified malleable the role played by manganese becomes of secondary importance.

6. Cracks and hot tears are generally eliminated in castings where these are common problems.

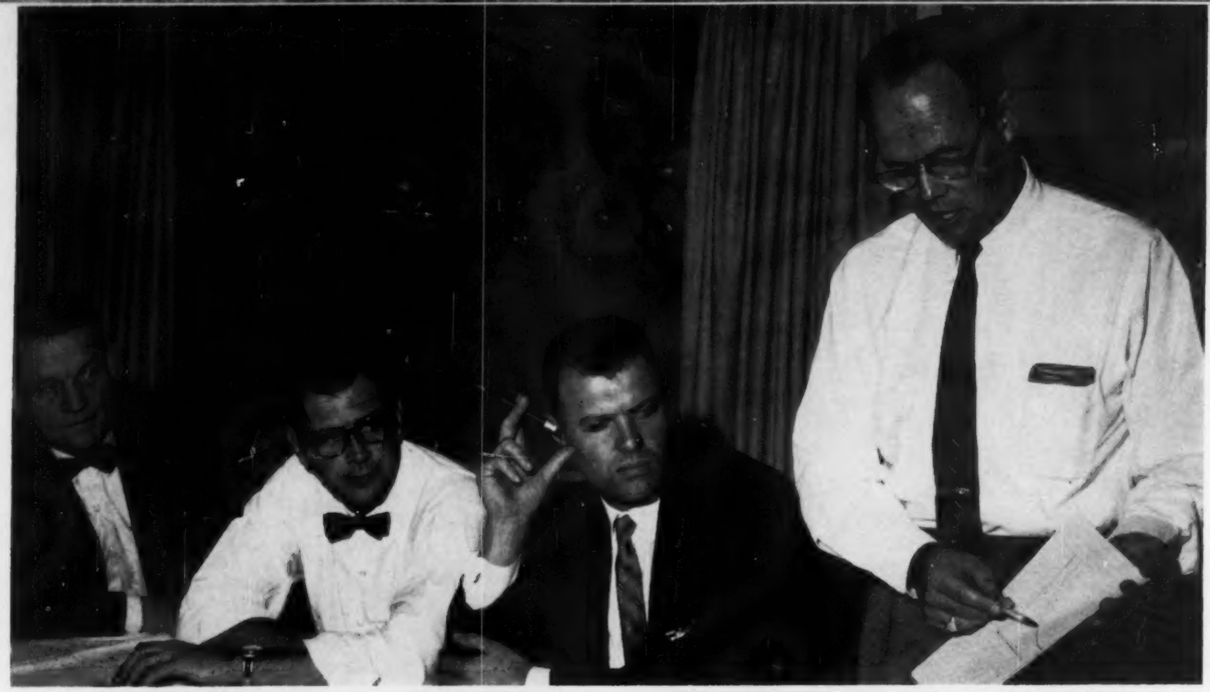
7. Section size is no longer a critical factor, as it will cast free from flake graphite when controlled variation of silicon-carbon is desired.

8. Magnesium is not retained in the subsequent metal after remelt—the case of most carbide stabilizers.

9. Magnesium is compatible with many elements and does not require catalysts or agents to overcome reactions that occur when some carbide stabilizers are used.

Patents for the improvement process of malleable iron and the forms and types of pure magnesium introduced into a molten iron process have been applied for in the name of Everett Hale and Harry Laudenslager, Jr.

A. E. Schobeck is enthusiastic about the new processes and the market potentials they may open up for the company and the malleable industry. Production of both types of castings gives the company a great flexibility in the appeal to the casting user.



Ahti Erkkinen, Andrew Jenckes, and Harry Sleicher give full attention to Lee Burgess explaining how he uses a Pareto curve in statistical analysis of avoidable costs such as scrap and breakdowns.

MC MARKETING SEMINAR

Gear for Tough Times Despite Good Business

• *European Competition Will Move In*

• *Low Profit Margin Will Continue*

Remedy: Use modern marketing methods. Mechanize where possible.

Stress sound cost-savings techniques.

Sell castings before end-use products get to the drawing board.

Fight for a realistic depreciation policy.

DESPITE a highly favorable forecast for metalcasting in 1962, rough competitive days are ahead. Metalcasters must accept this fact and reshape their business and technical operations accordingly.

This was the consensus of the second MODERN CASTINGS trends seminar, held recently in conjunction with the AFS New England Regional.

Focusing on quality control, cost control, and sales development, seminar participants found four problem areas which must be tackled firmly and at once:

Problems Ahead

1. Greater competition from the European common market, particularly in the next two years.
2. A continuing unfavorable depreciation climate, for capital goods especially.
3. A dangerously low profit margin.
4. A continuing lag in marketing and sales know-how by

Frank Tibbetts and Robert Ashley take time out for making notes.

Harry Ahl reflects on a point of concern.

metalcasters as compared to competing industries.

What should be done? Some six ways were suggested:

Suggested Remedies

1. Sell castings *before* the designer sits down at his drawing board.
2. Reappraise plant cost operations in relation to their total effect—whether or not sales result.
3. Institute modern cost savings methods.
4. Take positive action to obtain a better depreciation policy from the Federal Government.
5. Know the "life cycles" of end-user products—a big help in building business and maintaining a sound sales position.
6. Fight for a more favorable attitude towards business by the Federal Government.

In other words, the thinking of the seminar participants was that metalcasters must look hard at ALL metalcasting operations. They must rearrange departmental operating relationships on a sales-result basis. They must develop carefully integrated cost control and marketing programs. They must put more emphasis on specialized sales techniques.

Does this pay off? A poll of the seminar provides an indication:

... Most reported that emphasis on better quality control has resulted in more repeat business in their plants. Initially, higher costs resulted. For most, a closer working relationship with design engineers resulted. New business, though slow in developing, was a key result for many.

Technology Not Enough

Highly significant was the premise advanced that technological improvements are not enough. Modern business methods and sound marketing techniques are also absolutely essential.

It was generally agreed that more aggressive sales efforts are needed. Comment included:

... For today, this means punching doorbells. For the long range it means contacting the design people to specify castings. For a still longer range, it means diversifying and getting one's own product.

... Get the product before potential customers by going to design engineers. Have an educational program to show cost advantages of castings as compared to other products, such as weldments.

... Stop "crying the blues" and think constructively. Develop a castings attitude among customers. Give more attention to the customer's needs and problems. *Produce* and *sell parts*, not just castings.

Considerable interest was shown at the seminar in the prediction that European Common Market competition will hit domestic metalcasters hard in the next 18 to 24 months.

Advantages coming from improved casting techniques and management practices abroad were cited:

... Improved mechanization (chiefly through labor-saving devices and more efficient use of labor).

... Closed circuit TV for plant communications.

... Chemical analysis before metal is poured—a practice in most leading European plants.

... 80 percent of molds poured automatically in many automotive metalcasting plants.

... High hourly output of good castings.

... Modern melting equipment and methods such as high frequency current for cold charge melting, and switchover to line frequency in same furnace.

... Wide use of Teleautograph equipment.

Emphasized strongly was the favorable attitude of governments abroad towards their industries. Favorable depreciation policies (one-year and three-year write-offs) were a big factor in stimulating technological advance *and increased business.*

Seminar Participants

Frank Tibbetts
Vice President
Wollaston Brass & Aluminum Foundry, Inc.

Robert Ashley
Manager Manufacturing
American Radiator & Standard Sanitary Corp.

Harry Sleicher
Vice President and General Manager
Seaboard Foundry, Inc.

Harry Ahl
Sales Manager
Malleable Iron Fittings Co.

Ahti Erkkinen
General Manager
Fremont Castings Co.

Andrew Jenckes
Treasurer
J. S. White Co.

Lee Burgess
Vice President
Belcher Malleable Iron Co.

Harold E. Green
Managing Director
MODERN CASTINGS

Jack H. Schaum
Editor
MODERN CASTINGS

Casting a Heartbeat

Now—spare parts for hearts. Mass produced investment castings can play a vital role in saving a human life.

By LEO E. CARR
Special Projects
Precision Metalsmiths, Inc.

1. Wax patterns and PMI hollow sprue form production setup and gating system. Unit carries 36 male or 60 female heart parts.

INVESTMENT CASTINGS so reliable that they become part of the human heart are being produced by Precision Metalsmiths, Inc., Cleveland. For the first time, production castings are used to repair defective hearts — a breakthrough in the research of mass producing spare parts for people.

R. R. Miller, investment casting specialist and president of Precision Metalsmiths, was called upon to help design the heart valve as a casting. Since the part needed to be corrosion resistant and impervious to body chemicals, a cobalt base alloy, AMS 5385, was selected. This alloy is of uniform grain structure, high density, and virtually impossible to machine.

Miller established design of the part and its castability by use of the PMI Cast Prototype Service. The Starr-Edwards medical team tested several experimental valves by vivisectional research to prove design and function of the part before its release to production and final use in human hearts.

The valve casting is cage-like in design and made in several sizes to fit any heart. The cage, formed of four ultra-thin struts—each measuring 1/16 x 3/32 x 1-3/8 inches—is cast to a ring base of 1-1/8 inch diameter to form an integral unit. The heart casting weighs one-half ounce. These are average dimensions and weight.

Pilot casts established the production run of parts. Metallurgically sound castings were produced by use of the PMI hollow sprue and ceramic shell mold. Other gating and molding systems tried produced cold shuts in the curved sections of the long thin struts, shrinkage cracks at the intersection of the four struts, and hot tearing at the juncture of struts and ring base.

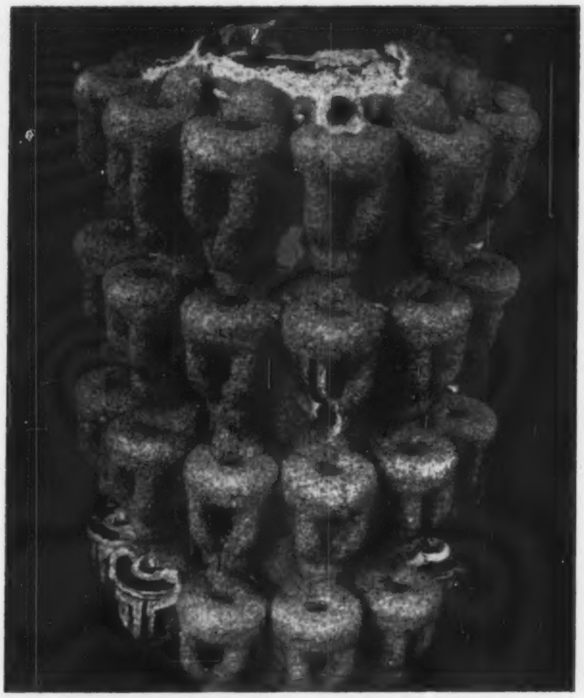
The production gating system uses a ¼ to ½-inch tapered hollow sprue—3½ inches in diameter by 12 inches high—carries 36 male or 60 female heart parts.

The use of a ceramic shell eliminates metal-mold reaction and parts are cast with a 32 rms surface finish. All ceramic molds are cast within a vacuum chamber. The hollow sprue gating system and ceramic shell create the correct thermal gradient in the cast set-up to produce optimum soundness in the castings. Rapid solidification of cast parts—10 to 12 seconds—provides the desired fine grain structure and impermeability of the metal. After gate removal, the parts are buffed to a mirror-like finish. The parts are used without further metal-working operations.

The investment casting is formed into a small valve which replaces a defective mitral valve of a heart. This new-type prosthetic performs a true valvular function within the heart and, when used, is essential to sustaining life. The artificial heart valve was conceived by Dr. Albert Starr, assistant professor of surgery at the University of Oregon Medical School, and M. Lowell Edwards, a Portland inventor and engineer.

Known as the Starr-Edwards mitral valve, it is the first human mitral valve replacement to permit patient survival beyond a three months' period. The artificial heart valve is the acme of simplicity. Patients received the first replacements more than a year ago and are enjoying normal life today. They can look forward to a normal life span from all observations.

The Starr-Edwards mitral valve is of simple, ball-check design and hydraulically perfect. A ⅞-inch silicone rubber ball moves freely within the cage and fits a seat in the ring base. The outer



2. Ceramic shell mold and its cast set-up. Parts of shell are cracked away to reveal cast parts. Use of ceramic shell eliminates metal-mold reaction.

3. As-cast detail is pictured here. Parts are cast with a 32 rms surface finish. They are buffed to mirror-like finish after gate removal.

margin of the ring base is covered with knitted Teflon cloth into which sutures are sewn to hold the valve in the heart.

Prior to human use, the valves were subjected to accelerated testing that equaled 45 years of service. The valves showed no appreciable wear or corrosion.

The mitral valve in the human heart connects the left auricle and left ventricle. The auricle is the heart's chamber which receives the newly oxygenated blood coming from the lungs. The ventricle is the heart's strongest pumping chamber and forces blood out through the arteries to all parts of the body. Through disease, such as rheumatic fever, the mitral valve may become calcified, inflexible, and unable to function properly so that blood surges backward to cut down the power of the ventricle. Unless this condition is corrected, it will disable a person for active living and may cause death.

When a calcified mitral valve cannot be repaired by other means, the Starr-Edwards mitral valve may be used. During open-heart surgery the damaged mitral valve is removed from the heart, the artificial valve is inserted, and the orifice of the ventricle is stitched to the Teflon ring. When surgery is completed, and the heart beats, blood pressure from the auricle forces the silicone rubber ball against the valve seat, closing the valve to permit the blood to flow in its proper direction. The patient is unaware of the artificial valve except for the relief it gives.

4. The Starr-Edwards mitral valve, first artificial heart valve to replace human mitral heart valve.

New Growth Slated in 1962 for Die Casters

Tackling markets held by stampings, extrusions, forgings and other methods, die casters express open optimism about the future. The process is a key factor in mass producing a stream of consumer and industrial items of complex shapes and sizes. Automation and improved die steels for better production will improve their competitive position.

What's Being Done for Die Casters!

- *Ultrasonics have helped in casting thinner sections, producing stronger castings, better surface finish.*
- *Vacuum techniques eliminate pin holes, improve metal fluidity.*
- *Improved die steel withstands higher temperatures, erosion, and thermal shock.*
- *Ultra high injection pressures of 50,000 psi raise casting properties.*
- *High silicon aluminum alloys increase wear resistance of castings.*
- *Large die casting machines approaching 100 pounds per shot.*
- *Hot metal die casting plants operating adjacent to primary aluminum smelters.*

THRIVING in a highly competitive atmosphere, die casting is on the verge of a growth phase that will affect the entire metalcasting industry.

Ask a die caster what market he is after and he says: "You name it, and we will be doing it some day. If it can be cast at all, it can be die cast."

This optimism is based on fact. The process has entrenched itself as a key factor in the manufacture of a never-ending stream of consumer and industrial goods of complex shapes and sizes. The most talked about today is the die cast aluminum engine block, one of the most complex configurations in commercial production.

Die castings have changed the physical appearance of thousands of commonly used products. They have invaded the domain of many other metal and plastic fabrications with a high degree of success. The entire competitive field of stampings provides a reservoir of market opportunities for new applications.

What are the advantages of die casting? The men in the industry will point to mass production economy, to precision at high speed, to a minimum labor requirement, and to a highly divergent product list which keeps a plant busy.

Rely on Consumer Use

The demand for die castings depends heavily on the output of "hard goods" (consumer durables), and this has its effect on the production tonnage. Automobiles take the greatest share of the castings produced, but home appliances and other household and recreational items swallows millions of die castings each year, castings that can be colored, plated, and painted, falling into the multi-million dollar decorative and fad markets.

While automobiles and home appliances consume the greatest quantity of castings, many other industries are asking die casters to solve their problems. On the

Who Uses Die Castings and How Much

Totals represent all job shop sales, estimated in pounds in 1960. Captive use not included. Source: American Die Casting Institute.

	Zinc		Aluminum		Magnesium		Brass	
Agriculture, mining, construction	4,600,000	1.1%	7,800,000	3.6%	......	......	45,000	0.6%
Automotive	208,600,000	49.8	75,400,000	34.7	460,000	10.6%	650,000	9.0
Other transportation	5,000,000	1.2	2,800,000	1.3	12,500	0.3	25,000	0.3
Machinery and tools	40,200,000	9.6	30,500,000	14.0	2,250,000	51.7	1,100,000	15.3
Electronics	7,500,000	1.8	3,000,000	1.4	180,000	4.1	......	......
Office business machines	18,000,000	4.3	16,900,000	7.8	300,000	7.0	95,000	1.3
Plumbing, heating, hardware	32,650,000	7.8	10,850,000	5.0	......	......	4,600,000	63.9
Optical, recording devices	12,150,000	2.9	17,500,000	8.1	424,000	9.7	170,000	2.4
Timing devices, clocks	7,950,000	1.9	2,600,000	1.2	18,500	0.4	45,000	0.6
Home appliances	76,100,000	18.1	37,500,000	17.3	240,000	5.5	120,000	1.7
Toys, sporting goods, jewelry	5,000,000	1.2	8,250,000	3.8	40,000	0.9	200,000	2.8
National defense	1,250,000	0.3	3,900,000	1.8	425,000	9.8	150,000	2.1
Totals, 1960	**419,000,000**	**100.0**	**217,000,000**	**100.0**	**4,350,000**	**100.0**	**7,200,000**	**100.0**

West Coast, in the heart of one of the leading space age technology centers, the Western Die Casting Co. is reaching quality levels which its president, A. W. Simpson III, term "undreamed of only a few short years ago."

L. E. Capek of Du-Wel Metal Products, Inc. points up the fact that his company has been asked to produce castings of much thinner wall construction and more utility and beauty. New applications which are absorbing time and study include casting precious metal gold plate on a scale never before attempted, he said.

Many Fields to Work

Samuel A. Gullo, Chicago White Metal Castings, Inc. looks at machinery, tools, electronic devices, business machines, space hardware, and other defense materials as naturals for die casting firms that will "dig, cultivate and work" in these fields. He points to lighter weights, thinner walls, finer finishes, smaller and larger castings, precise dimensions and difficult, complex castings as coming trends.

American metalcasters have been die casting for some 60 years, but the spectacular growth of the process came in the past decade. This growth factor is not at a leveling off period yet. Since 1952, about 80 per cent of the 10,600 die casting machines now in use were installed. The metalcasters are looking for bigger and bigger machines all the time. The increased rate of output of die castings has been about double the rate of growth of the gross national product.

Metal for metal, zinc is still the weight champ. Aluminum is a fast-rising second, and magnesium is a dark horse fourth. Brass is still limited in growth by the need for improved die metals.

As it stands today, it is possible to get a million shots per die when casting with zinc. Magnesium offers some 250,000 shots, and aluminum still gives 100,000 shots. Only 5000 shots are possible with brass and bronze.

Die casters state that a die which will have a life of 100,000 shots for copper base castings will break open whole new markets and, in their words, "create a whole new industry." This, however, awaits the advancement of technology. Research programs in laboratories, universities and among producers are underway now, looking for the new die metal.

Magnesium Coming Up

In the race among metals for a bigger share of the die casting industry, magnesium is coming up strong. At the present rate of growth, magnesium die castings will soon pass magnesium sand castings in terms of annual tonnage. To encourage more widespread use of this light metal, its per pound price has been pegged to that of aluminum on a volume basis. Because magnesium weighs only two-thirds as much, the price advantage on a volume basis is obvious.

At the same time, magnesium producers emphasize that it has only two-thirds the heat content of aluminum. With less heat to dissipate during solidification, magnesium production is claimed to be from 50 to 100 per cent faster than aluminum.

There are problems as well as advantages. Magnesium cannot be cast as thin as zinc. About

0.070 to 0.080 inches is the thinnest possible using current methods. This compares favorably with aluminum but is about twice the thickness of the thinnest zinc casting.

Zinc in Top Spot

Zinc has no problem holding the number one position in die casting. In terms of production runs, it cannot be touched. Competitively, it holds claim to advantages in mechanical properties, physical constants, casting characteristics and cost (MODERN CASTINGS, August 1961, page 35).

Zinc die casters look for 10 to 20 per cent growth in demand during the next five year period. The automotive market still commands the majority of castings produced, and this is expected to increase. At the same time, there is a drive to broaden the base of products. Home appliances, household implements, decorative bezels, business machines, and computers (MODERN CASTINGS, November 1960, page 36) offer market opportunities in growing industries.

One of the brightest pictures painted by industry members is that by the aluminum die casters. They are unanimously optimistic about the future, predicting shipments of 1,075,000 lbs. of castings by 1965. (MODERN CASTING, January 1961, page 48). In a 10 year period, 1949-1959, aluminum die casting grew 418 per cent as an industry. Technology, in the form of bigger and better machines, improved injection equipment, and automatic equipment to cut labor costs are called the biggest benefits to growth.

The die casting industry, like the entire metalcasting industry, faces fierce competition from other forms of metal forming and plastics. Even with this competition, active and aggressive die casters are optimistic about their special field of metalcasting. They are confident that the next few years will bring as many new and revolutionary ideas to the industry as the past decade did.

Success with the die cast automobile engine block has inspired much of the die casters' confidence.

Doors and Decks Next

"Doors and decks may be next," one die caster predicted. "You'll see that all automobile engines will be light metals and die cast in 10 years," he added.

Die casting processes and advances in both the Western European and Russian dominated countries are showing progress. Following World War II, European countries rebuilt their industries and concentrated on the use of light metals. This is one good reason why some of the most modern and radical die casting equipment is in production there today.

A. Triulzi of Novate, Milan, Italy has completed testing a 2425-ton pressure die casting machine—the world's largest. It will produce eight-cylinder automobile engine blocks weighing 100 lbs. each at the rate of 20 an hour. This is mass production—yet only one operator is necessary.

In Russia, they say they are die casting gray iron and steel successfully. There are no similar facilities in this country because the cost is considered prohibitive now. This does not eliminate study and research.

Must Become Automated

American die casting potential was well expressed by Murray J. Laub, executive vice president of Hartzell Mfg. Inc., St. Paul, Minn. Said Mr. Laub: "To improve its competitive position, the industry must become completely automated. We must take bold ventures and change design of tools. We must bring about aggressive selling in service policies that have been established in other industries.

"Let's not sit and worry about competition, but figure out how to do the job better than they do."

In Germany, in 1960, each Volkswagen produced carried 44 lbs. of magnesium castings. They made one million cars, so a total of 44 million lbs. of magnesium cast parts were produced. In the United States, the entire production of magnesium castings of all kinds totaled 23½ million lbs. last year.

The European advances coupled with keen competition at home seem to inspire die casters rather than discourage them. Individually and collectively they express a willingness to improve their products to meet the customers' demand. They are also fully aware that the need for diversification is paramount. They are certain they will have more automotive business in tons of castings, but they want this to represent a smaller segment of their over-all production. This is a healthy approach to building a growth industry.

THE CONTRIBUTORS
To Market Opportunities

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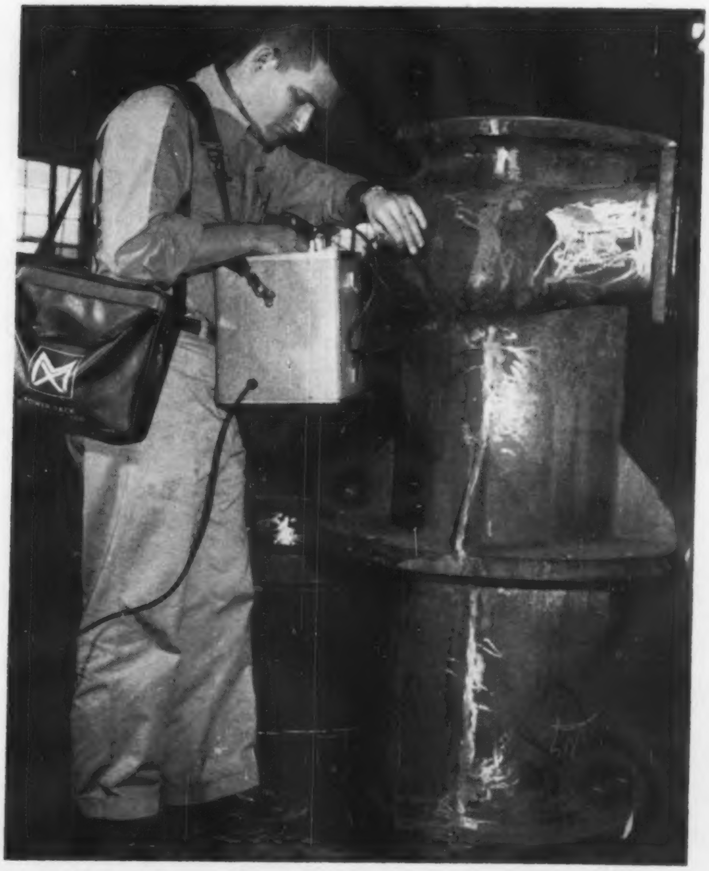
Measuring Wall Thickness Is No Problem

Engineers at American Cast Iron Pipe Co. have cut the time and cost of measuring casting wall thickness by using ultrasonic testing devices to get at the tough spots.

For the first time, 20-foot pipes can be measured from end to end with equal accuracy, and diameter checks can be made while the tube is in the lathe.



Harold Hartline, mechanical engineer in the inspection department, checks wall thickness of a rough, 16-foot ductile iron uniclone casting using the ultrasonic measuring device.

ULTRASONIC MEASURING of casting wall thickness, using an electronic device, is saving time and money at American Cast Iron Pipe Co.

The Birmingham, Ala. foundry has reduced measuring of as-cast and finished irregular-shaped castings and long tubes to a simple operation. The direct reading, inspection units are used to evaluate rough castings before machining, during machining, and for the final check out. Management reports less than one per cent error in accuracy since ultrasonic equipment has been put to work.

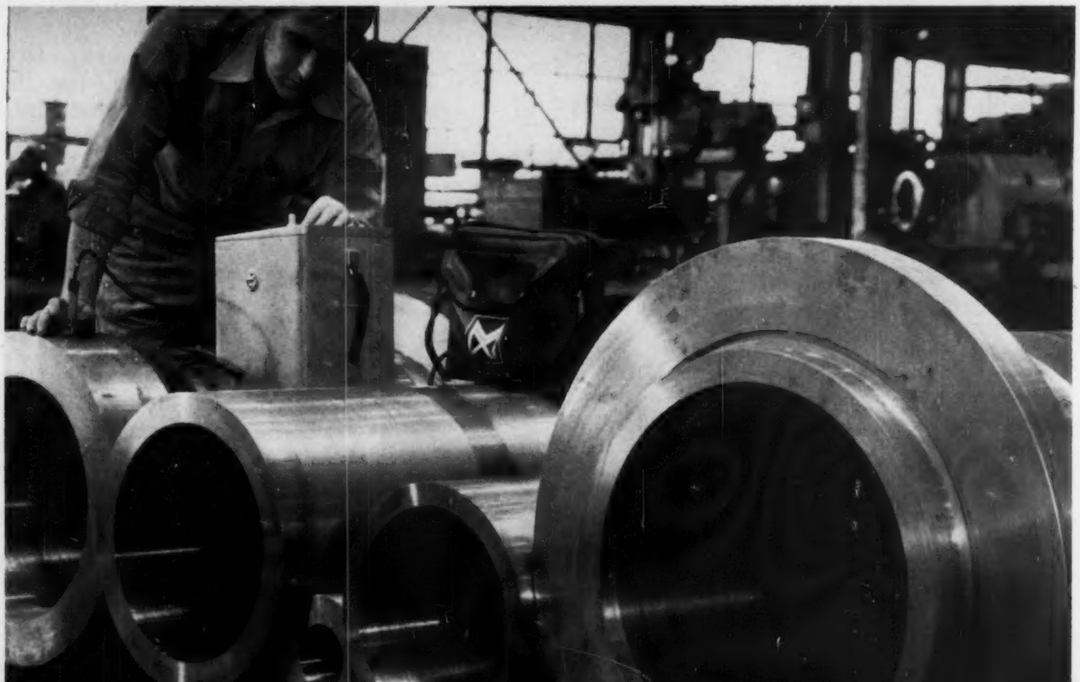
Henry J. Noble, superintendent of the inspection department at ACIPCO, said the device is used on castings with wall thicknesses of from 0.025 to 2.50 inches. Accuracy depends upon the type of material and how great the wall thickness, he explained, but the units are producing more information on castings such as an irregular-shaped pump shell, than ever obtained by other methods.

Cost Is Reduced

Cost of detecting wall thickness has been substantially reduced, he added. The unit is portable and battery-operated, so it doesn't have to tie into power sources in the foundry. Measuring takes place on the spot. One advantage is that preparation of the material to be measured has been minimized, and another is that the units permit quick, direct numerical readings.

Wall thickness of 20-foot as-cast tubes can be measured from end to end with equal accuracy. The unit explores the middle of a long tube which was previously inaccessible to calipers, micrometers or other instruments. The ultrasonic device also permits diameter checks of a tube while it is being bored in a lathe. This eliminates time

Hartline checks the center of a 20-foot steel tube for as-cast wall thickness. This job, he said, once took several hours just to set up. Now the wall thickness can be measured in a matter of minutes.



Huge cylinders such as these can be checked for proper wall thickness right in ACIPCO's machine shop by the portable unit.

wasted when the tube had to be removed from the lathe for each measurement.

In preparing for a measurement, the operator rubs a drop of liquid glycerine onto the casting. He then presses a small transducer (which resembles a tiny microphone) against the metal wall and switches on the instrument. He matches a dial on the unit with a series of lights, and the reading is complete.

Ultrasonic inspection devices can be used to test thickness of steel, cast iron, brass, aluminum and other metals. It will actually measure any solid material which transmits ultrasonic sound. A range of ultrasonic frequencies are passed from the transducer into the test piece. At resonance, which corresponds to the thickness of the wall, there is a return of sonic energy to the transducer. This is amplified and shown as flashing points of light on the unit. Each flashing light represents a harmonic of the true thickness of the metal. Calibration takes about two minutes.

Three Frequency Ranges

There are three ultrasonic frequency ranges—white, red, and green. The recommended ranges which may be easily measured with the instrument are: White—0.225 to 0.600-inch; red—0.405 to 1.15-inches; and green—0.720 to 2.0 inches. The instrument is oriented for individual materials by the insertion of that material into the machine. Standard quartz transducers—flat and curved—are available for all ranges.

The tool is primarily used for the special products division, Noble explained, since most of the castings are made to close tolerances. It is, however, used to a limited degree to evaluate pipe wall thicknesses and to measure static castings.

"We are using it on a broader basis as we go along," he concluded, "in an attempt to learn how we can use it to best advantage. We expect that it might ultimately become a routine production tool in our operation."

It is a simple matter to check a large-diameter tube as it is being bored in a 50-inch lathe. There is no need to stop the operation or remove the tube from the lathe.

How Ultrasonic Testing Is Used

Here are several specific examples of how foundries are measuring casting thicknesses with ultrasonics.

Material	Type of Part	Problem
Carbon and alloy steel	Axle housing for tractors	Core shift
Gray iron	Steam turbine covers	Core shift
Gray iron	As-cast bath tubs	Wall thickness
Magnesium	Helicopter housing	Wall thickness
Gray iron	Automotive blocks	Wall thickness between cylinder bores
Aluminum	Die cast blocks	Core shift in wall
Steel	Axle housing for fork lift truck	Core shift
Gray iron	Practice bomb	Wall thickness

Air Condition a Foundry?

Not such a wild idea if it will help cut absenteeism, reduce the cost of making castings, and eliminate sand moisture problems. This is what they learned at the Leslie Co. when they completely air conditioned the foundry.

Conditioned air from a central air treatment unit flows into the foundry through the ducts pictured along the wall, forcing hot, fume-laden air out of roof exhausts.

AIR CONDITIONING an entire foundry may sound "way out" to metalcasters. In fact, many look at the foundry as the last manufacturing facility that could be air conditioned, if at all.

"Not so!" says John S. Leslie, president of Leslie Co., manufacturers of regulators and controllers for industrial power process systems and marine power plants. As a result his plant at Lyndhurst, N. J. has what he believes is the only fully air conditioned foundry in the world.

Metalcasters can afford to take heed when he points out that air conditioning his foundry has:

(1) Reduced shutdown time and increased production

(2) Reduced the per-ton cost of making castings

(3) Increased employee morale and efficiency

(4) Eliminated the major problem of sand moisture control.

"Because of the nature of the work," Leslie explained, "the foundry should be the first place air conditioned."

He points out that foundries are hot and humid in the summer and cold and damp in the winter. It takes large quantities of outside air circulating to dissipate steam, smoke, and fumes which would otherwise build up and make conditions unbearable. Rapid changes in this outside air can change the moisture content of vitally needed sand and slow down foundry production at any time in summer or winter. If air conditioning would remedy these conditions, Leslie reasoned, then it is worth the expense.

The Leslie Co. now has some 90,000 square feet of air conditioned areas, ranging in size from a 20,120 square foot office to the 550 square foot pattern shop.

The 6,900 square foot foundry is a pivotal department in the company's manufacturing operation. In it, 39 employees produce castings for pressure vessels. These must meet a high degree of non-porosity. It is one of the few foundries which make castings capable of withstanding steam and water pressures as high as 600 psi and 1000 psi respectively, a fact which has helped the company triple its 1950 volume in 10 years while maintaining employment at the same level.

It was necessary, Leslie said, to bring in an air conditioning manufacturer, the Carrier Air Conditioning Co., because a check of engineering and contracting firms revealed there were no other "climatized" foundries which could be used as examples.

Many contractors were reluctant to attempt the job because of such formidable problems as:

(1) Removing the high heat loads created in the manufacturing process

(2) Preventing air currents from affecting the cooling of castings

It takes a bank of overhead ducts to carry away the contaminated air and dust released during casting shakeout. Individual areas within the foundry were given individual attention during planning.

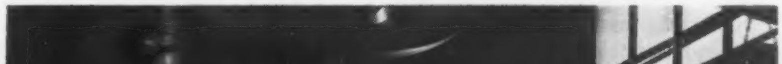
(3) Maintaining satisfactory temperature, summer and winter, plus humidification and dehumidification as needed.

(4) Preventing radical temperature changes for workers between spot cooling at working stations and the rest of the foundry. (Installation of a central system was initially ruled out as "economically impossible" despite Leslie's willingness to overlook cost at the outset of the study.)

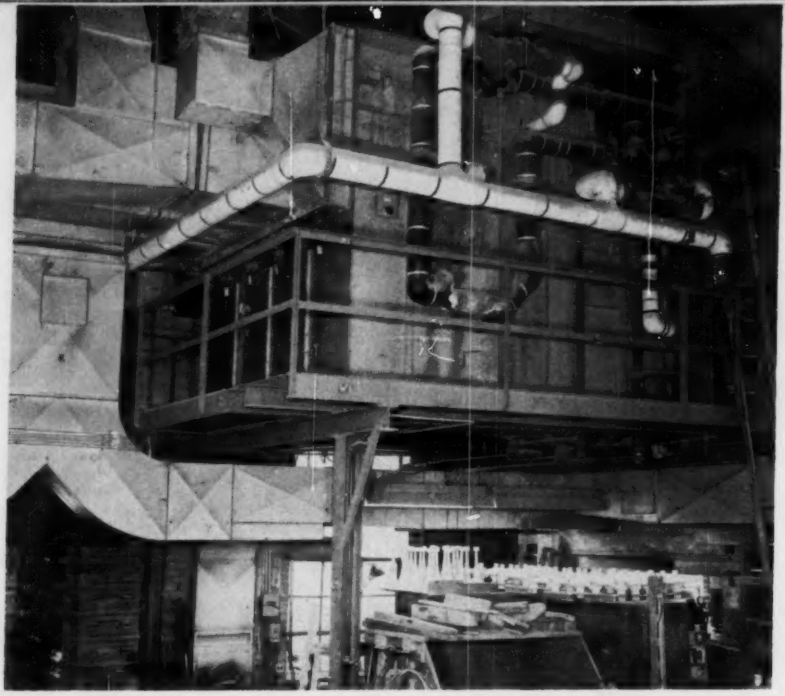
Face Many Problems

After the initial study was completed and a working plan drawn up which covered all the problem areas, Leslie awarded the contract to a local dealer. The system, as designed, has worked to meet the full expectations of the company.

There were many problems inherent to a foundry that had to be overcome. The system in-



Another example of individual area treatment is pictured at this steam test station. A battery of overhead diffusers bathes workers at each test stand in a shower of cool air, quickly dispelling the excessive heat generated by inspection.



The central air conditioning unit for the foundry is located on a specially constructed mezzanine within the building it serves. It uses plant steam and well water to condition the foundry air.

troduces specified quantities of air at low velocity through 36 outlets located close to the floor. In the shakeout and cleaning room, 20 outlets are located on the side of an overhead duct. Seven ceiling diffusers are located in adjacent foundry areas.

The large air volumes entering at the work level force air out through exhausts located in the roof. In this way, all gases and fumes are carried off, maintaining a constantly fresh atmosphere on the work floor. No air conditioned air is recirculated, so filter cleaning is minimized.

Build Special Platform

Another design innovation was forced by the foundry's overhead cranes. The two-story rectangular building has a pitched roof. Against the two long walls is a heavy wooden frame which supports two overhead cranes extending nearly the full length. This frame made it impractical to feed conditioned air down from above the crane, and vertical supports holding the crane's track aloft prevented the installation of ducts along the walls.

Instead, a built-up air treating unit, which delivers 30,000 cfm of conditioned air to the foundry, was located on a special platform in one corner of the building just under the roof. From this level, two supply ducts from the unit were wrapped around the outside of the building. Take-off branches pierce the building just beneath the crane track and extend down the wall almost to the floor.

Some of these ducts end very close to working employees. To eliminate annoying blasts of air, three separate openings of two different sizes were made in the end of the duct to gently diffuse the required air volume into the main foundry area. Directional louvers on the two largest openings nearest the floor permit workers to receive a mild flow of air without being in the main stream.

The large volume of air entering at the work level maintains enough pressure inside the foundry to prevent outside air—hot or cold—from entering the foundry when the doors are opened. This maintains a desired temperature level and controls humidity while eliminating annoying drafts that could hinder the cooling of castings.

Design conditions provide for a room temperature of 77°F dry bulb and 60 per cent relative humidity with outside air at 95°F dry bulb and 75°F wet bulb.

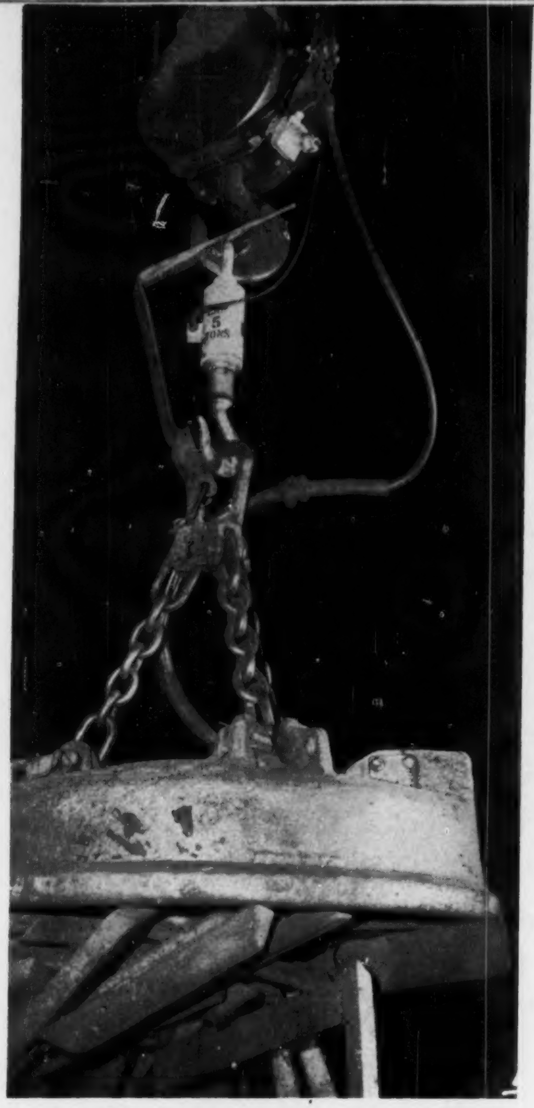
The central air handling unit is equipped with both preheat and reheat coils using plant steam. Cooling is supplied by 200 gallons per minute of well water at 56°F, which is pumped to an eight-row cooling and dehumidifying coil with 100 tons capacity.

Cost of the installation was slightly less than an estimated $75,000, and the owning and operating cost has been well within the original budget allowance.

Savings Are Evident

Management at Leslie admits that actual dollar and cents savings directly attributed to air conditioning would be difficult to pin point because of many variable factors. The facts, however, are self evident. There has been a noticeable decline in absenteeism because of temperature extremes in summer and winter. There has been an increase in foundry productivity–which can be influenced by many factors. There has been a reduction in the per ton cost of making castings. The latter is important because it justifies the original investment.

Summarizing his enthusiasm for air conditioning, Leslie concludes: "We are a comparatively small concern; we must make investments that pay off. We believe this installation represents money well spent."



Load cell links crane and magnet. A grab bucket is used on non-magnetic materials.

Electronic Scales Weigh Cupola Charge

Today, the crane operator can handle the whole charge weighing operation from his cab.

Electronics make it easy to determine charge load, and all the calculations are automatic.

Calculator in crane cab instantly shows operator amount of additional metal needed to complete charge.

QUICK, ACCURATE, remote weighing of cupola charges saves manpower and improves quality control at the Fairbanks, Morse Co., Beloit, Wis.

These benefits emanate from use of a load hook containing a built-in electronic scale. The load scale converts pressure into an equivalent amount of electrical output which actuates electronic instruments for foolproof weighing. The weight is shown on a dial indicator and recorded on a tape.

The crane operator conducts the entire operation from his cab. A system of charge sheets guide him in making up the charge. A dial indicates the weight of pig iron or scrap lifted by the electric magnet. Each time the crane operator picks up a load he presses a button which records the weight. A sub-total on a calculator in the cab shows the amount of additional metal needed to complete the charge.

The regular crane hook slips through an eye on top of the load cell and a hook on the bottom picks up the magnet. For handling non-metallic charge materials such as coke and limestone, a grab-bucket is easily substituted for the electric magnet.

Prior to any weighing, the dead or "tare" weight of the bucket, magnet, chains, etc., are balanced off by merely turning a knob on the indicator.

With this installation Fairbanks, Morse eliminates the need for another man on the charging floor to read the scale.

METALGRAMS

UNION CARBIDE METALS

. . . news of "Electromet" ferroalloys and metals

DECEMBER 1961

CUTS COSTS OF ACID-MELTED DUCTILE IRON -- Since acid-cupola slags don't desulphurize, acid melters of ductile iron must use low-sulphur raw materials that are high in carbon and low in phosphorus. Hence, they must use large amounts of special pig iron with little steel or revert scrap. "EM" foundry carbide, a new exothermic material added to the cupola, allows use of lower cost charge materials. It does so by raising iron temperatures, so that carbon absorption and silicon recoveries are increased. Thus, melters can use more scrap and less special pig iron.

* * *

IMPROVES DESULPHURIZING POWER OF BASIC SLAGS -- When "EM" foundry carbide is used in basic melting of ductile iron, sulphur is reduced to extremely low levels. The reason: the carbide increases slag basicity, lowers its iron-oxide content, and raises its temperature -- all of which improve the sulphur-holding capacity of basic slags. Lowering the sulphur content increases the efficiency and reduces the cost of the magnesium treatment. For more information and production experience with "EM" foundry carbide, write for booklet F-61-0119 or circle 144 on page 133.

* * *

REDUCED INVENTORIES CUT COSTS -- Fast delivery of ferroalloys from one of Union Carbide Metals' 39 distribution centers allows metal producers to reduce inventory costs. Why? Large ferroalloys inventories are no longer needed. Purchases can be made to meet current ferroalloy needs. UCM has a plant or warehouse in every major metal-producing area in the country. Thus, delivery to your plant has been reduced from days to hours.

* * *

IMPROVED PACKAGING AND HANDLING, TOO -- Union Carbide Metals has also reduced customer handling costs by developing better packaging and material-handling methods. UCM introduced dump trucks for bulk deliveries of alloys. It has long used railroad container cars. Special shipping and unloading techniques have often been developed to meet a customer's particular conditons. UCM also played a leading role in the development of pre-formed alloys such as bricks, briquets, and pigs, and pre-weighed packages such as bags, cans, drums, and box pallets. For more information on distribution centers and alloy shipments, write for the article, "More Efficient Ferroalloy Distribution," in the Fall 1961 issue of UNION CARBIDE METALS REVIEW or circle 145 on page 133.

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UNION CARBIDE METALS COMPANY, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, N. Y. In Canada: Union Carbide Canada Ltd., Toronto.

AFS New Technology-1961

December Contents

About the New Technology

These nine New Technology breakthroughs represent the final report on metalcasting advances in 1961.

Beginning with the January issue, MODERN CASTINGS will preview 1962 New Technology—selecting top American and international breakthroughs for a first-time presentation.

All of the New Technology for 1962 will be presented before the combined 66th AFS Castings Congress and 29th International Foundry Congress in Detroit's Cobo Hall, May 7 to 11.

Both American and international papers have been qualified as new contributions by technological committees working in cooperation with S. C. Massari, AFS technical director.

NEW HIGH STRENGTH DEZINCIFICATION RESISTANT BRONZE CASTING ALLOY

by A. H. Hesse

ABSTRACT

Foundry characteristics including pouring temperature, sand, melting practice, gating and risering of a new dezincification resistant alloy are presented. Also included are data on the alloy's chemistry, mechanical properties, machinability, corrosion resistance and electrical conductivity. Applications are suggested. A method for production of internally sound value stem castings is also presented.

OBJECT

Specification 8959 for Double Disc Gate Valves in paragraph 2.7 Bronze Catalogs material for valve stems states:

> "a. Valve stems shall be cast or forged from bronze having a tensile strength of not less than 60,000 pounds per square inch, a yield point of not less than 30,000 pounds per square inch, and an elongation of not less than 12 per cent in two inches.
>
> "c. Bronze for all interior parts of valves shall contain not more than 2 per cent aluminum nor more than 7 per cent zinc. Heat treatment may be used to develop the desired strength characteristics."

The Department of Water and Power of the City of Los Angeles in these two paragraphs definitely limits the bronzes which can be used for valve stems to only a few.

Of the few qualified alloys, each has an undesirable characteristic which most consumers would prefer that the material did not possess. For instance, manganese bronze which foundrymen have learned to handle is not desired because it dezincifies; aluminum bronze which foundrymen have learned to tolerate dealuminumizes; silicon bronze does not have enough as-cast strength; silicon brass has too much zinc, and not enough yield strength; wrought silicon bronze must be work hardened to meet mechanical properties; and nickel-tin bronze must have practically no lead in order to meet mechanical properties by heat treatment.

Although manganese bronze, aluminum bronze, silicon bronze and silicon brass do not satisfy in one way or another the City of Los Angeles, these alloys have not been completely outlawed as a valve stem material in other locations. In fact, their use is still widespread in many other parts of the country, where they apparently are putting up an above average performance.

However, the City of Los Angeles has seemingly set a precedent for a valve stem material which must be more than satisfactory. This precedent is being adopted by others, one of which that can be mentioned at this writing is the City of Oklahoma City, Okla.

INTRODUCTION

Manganese bronze is a high strength casting alloy with suitable machining qualities that dezincifies under certain corrosive conditions. A noteworthy instance is found when this material is used as a valve stem. Depletion of zinc leaves the stem as a spongy coppery mass which sooner or later fails in service because of its weakened condition. Aside from its resistance to corrosion, manganese bronzes (A.S.T.M. B-132-52, Alloy A or B) are selected because they combine high tensile strengths (60,000 and 80,000 psi, min.), good yield strengths (20,000 and 32,000 psi, min.) and good elongation (15 per cent elongation in 2 in., minimum for both alloys). Both alloys have good machining qualities.

These alloys are still satisfactory valve stem materials. Certain valve consumers have written them out of their specifications because of their behavior in waters with higher pH than 9, or with a specific conductance or more than 350K x 10^6 micromhos per centimeter as determined in A.S.T.M. D1125-50T, as such water will remove zinc from bronze.[3] To retard dezincification in manganese bronze certain additives as 0.5 per cent tin have been found effective, though presumably not to a satisfactory degree in view of the pressure brought to bear by some consumers for a better material. For a time it was felt that aluminum bronze could be an alternative, or more suitable material. Reasoning behind this assumption was that mechanical properties approximately equal to manganese bronze were available in aluminum bronze in the as-cast condition. Moreover, it was felt that there would be no dezincification since no zinc was present in aluminum bronze.

This proved to be true except that a new corrosion phenomenon presented itself. It promptly was termed dealiminumization, and rightly so. This type of corrosion apparently parallels dezincification in

A. H. HESSE is Met. Engr., R. Lavin and Sons, Inc., Chicago.

manganese bronze, in that aluminum is depleted from the alloy. The corrosive media work their way through the material, gradually lowering its strength until failure results. Bearing in mind the chemical and mechanical requirements of the Department of Water and Power of the City of Los Angeles, such commercially available alloys as silicon bronze, silicon brass and a relatively new proprietary alloy are eliminated because of inability to meet all requirements.

For instance, silicon bronze (A.S.T.M. B-198-52, 12-A) meets chemical specifications but falls short on tensile and yield strength. Silicon brass (A.S.T.M. B-198-52, 13-B) fails on two counts. It contains more than 7 per cent zinc and falls short on yield strength, yet it is used successfully as a stem material in many valves.

The relatively new and patented alloy, also fails on one count—chemical composition. It contains more than 2 per cent aluminum and is restricted to 0.03 per cent lead in castings. The latter presents a problem of contamination to most foundries. However, it more than meets the minimum mechanical requirements.

Acceptable Materials

The materials which have been successful in meeting the City of Los Angeles requirements on all counts are wrought silicon bronze (A.S.T.M. B-98-58; Alloy D) and heat-treated nickel-tin bronze (A.S.T.M. B-292-56; Alloy A). One exception to the latter alloy must be mentioned. According to A.S.T.M. the heat treated nickel-tin bronze has 5 per cent elongation in 2 in. minimum. It is assumed that in actual practice the heat treated material has higher elongation, because the City of Los Angeles, where this alloy is accepted, requires 12 per cent elongation in 2 in. minimum.

Silicon bronze meets chemical specifications without qualifications, but must be upset and finished half-hard in order to satisfy mechanical properties. Upset collars are used to reduce machining time on valve stems. Some prefer to purchase half-hard rod with a diameter equal to or slightly greater than the O.D. of the collar. Machine shop scrap and machining costs are quite high for such stems considering the amount of stock required to meet O.D. of the collar. Nickel-tin bronze has been the only known commercial casting alloy which seems to satisfy the City of Los Angeles. It meets the chemical requirements and with a solution treatment followed by a precipitation heat treatment, meets the mechanical properties with the possible exception of elongation. Principal drawbacks to this alloy stem from the foundryman who shies away from heat treatment because he is usually not so equipped, and because it increases the cost of his product substantially. Moreover, the lead in the alloy must be less than 0.01 per cent in order to obtain a satisfactory response to heat treatment.

This also plagues the foundrymen who must procure sufficiently pure base metals and carefully segregate returns to the melting room to avoid contamination. Production volume on this type of material is usually small, therefore chances for contamination with lead are always present, since most brass foundries handle bronzes containing substantial quantities of lead. More than 0.01 per cent lead can be picked up by melting nickel-tin bronze in a crucible in which 85-5-5-5 had been melted previously.

In reviewing the characteristics of the alloys which satisfied the City of Los Angeles, it appeared that a market for a new alloy would be readily available, providing some of the shortcomings of the aforementioned materials could be overcome. Such improvements would incorporate:

1. Develop a casting alloy which would satisfy the City of Los Angeles in all areas without heat treatment.
2. Develop a casting alloy which would not be sensitive to contamination by reasonable amounts of lead, e.g., 0.25 per cent.

These objectives have been accomplished by the development of an iron-nickel-aluminum-silicon-zinc bronze. When prepared within the preferred chemical limits, the alloy meets the minimum mechancial requirements of the City of Los Angeles for stems in double disc gate valves. The chemistry and mechanical properties satisfy the City of Los Angeles without the need for heat treament. The alloy is not extremely sensitive to lead contamination, and therefore is a candidate for use in the majority of nonferrous foundries since abnormal policing is not mandatory.

MELTING PRACTICE

The alloy has been satisfactorily melted in oil and gas fired crucible furnaces and in the rocking arc type and high frequency type electric furnaces. This does not imply that other types of furnaces are unsatisfactory. It means only that melting has not been undertaken in the other types of melting equipment normally employed for copper casting alloys. Oxidizing melting conditions have been employed throughout the research with the exception of one test (Table 1). The results did not show any great difference in mechanical properties between oxidizing and reducing melting atmospheres. However, a series of tests may prove otherwise.

TABLE 1 — EFFECT OF POURING TEMPERATURE ON MECHANICAL PROPERTIES OF NEW BRONZE

HEAT NO. L44			
POURING TEMP., °F	TENSILE STRENGTH, PSI	YIELD STRENGTH, PSI	ELONGATION, % IN 2"
OXIDIZING CONDITIONS			
2150	59,500	26,000	18.4
2050	62,800	31,100	22.1
1950	69,100	32,300	28.1
1950	68,900	39,300	29.4
	REDUCING CONDITIONS *		
2000	63,400	30,300	21.8

* AVERAGE OF TWO TESTS

A subsequent test on another heat (101-1, Table 4), in which the chemistry was satisfied, but possibly because of a gassed metal condition, the tensile strength and elongation failed to meet the minimum require-

ments. A substantial difference then exists between, say a heat prepared under oxidizing conditions (Table 1, P.T. 1950 F) and one presumably gassed (Table 4, 101-1). The beneficial effect of a dry nitrogen treatment is also demonstrated in Table 4. The nitrogen treatment amounted to a 10 min purge in a melt superheated to 2400 F. Treatment was accomplished outside the furnace in a crucible. At the completion of the treatment the temperature had dropped to 2050 F. It was then allowed to cool naturally to 1970 F at which temperature the keel block was poured.

In order to eliminate the possibility that superheating rather than nitrogen was the beneficial factor, Heat 101-1 was prepared in the exact manner as Heat 101-3, excluding only the nitrogen treatment. The use of returns, e.g., gates, risers and once and twice melted pigs was employed in amounts to and including 50 per cent of the charge. No deleterious effect on either casting quality or mechanical properties was noted. In fact, a heat prepared in the foundry of a valve manufacturer containing only gates, runners, etc., produced the following mechanical properties after a 9 min nitrogen treatment beginning at 2375 F. The keel block test bars were poured at 1950 F.

Tensile Strength, psi	68,300
Yield Strength, psi	32,600 (0.2% offset)
Elongation, % in 2 in.	27.5
Reduction of Area, %	29.1

The precautions necessary for melting manganese bronze, aluminum bronze or silicon bronze are to be followed for this iron-nickel-aluminum-silicon-zinc bronze. There is evidence that lead can be tolerated without adversely affecting mechanical properties. Experimental work has been conducted in which 0.90 per cent lead produced these as-cast mechanical properties from a keel block test bar:

Heat 104-41	
Tensile Strength, psi	64,000
Yield Strength, psi*	31,500
Elongation, % in 2 in.	24.8
Brinell hardness (500 Kg load)	93

*Divider Method

However, other experiments with lead additions were not so successful. Heat 102-5 containing 0.49 per cent lead had the mechanical properties as-cast of:

Tensile Strength, psi	64,500
Yield Strength, psi*	43,900
Elongation, % in 2 in.	9.4
Brinell hardness (500 Kg load)	106

*Divider Method

In this instance, elongation is below the 12 per cent minimum of the City of Los Angeles requirements. Therefore, as a precautionary measure, and until more is learned about the alloy, lead is being held at 0.25 per cent maximum. Research has shown that no zinc replacement or other additions are necessary to achieve quality castings even though 2400 F is attained, so long as at least a 50/50 ingot-scrap return balance is maintained for each charge.

Although there may be other ways of degassing, best results for optimum mechanical properties have been obtained to date by the use of dry nitrogen. Quality commercial castings (i.e., valve stems) have been produced without a nitrogen treatment. Commercial castings should be heated to a temperature which will provide sufficient superheat to pour without misruns. No covers or fluxes have been employed. The melt is merely skimmed prior to pouring. It has been found that the amount of dross can be considerably reduced by avoiding unnecessary skimming and/or other agitation.

POURING TEMPERATURE

The pouring range for the alloy was determined by studying the effect of pouring temperature on mechanical properties and the minimum temperature at which certain commercial castings can be poured. The study relating to pouring temperature versus mechanical properties was conducted under oxidizing conditions in which 4 oz of cuprous oxide were placed on the bottom of the crucible, ahead of the 100 lb charge. Ten min prior to pouring, another 4 oz of cuprous oxide were added to the charge which had been melted under the oxidizing atmosphere in a gas fired furnace. The charge was allowed to cool from 2200 F without further additions to the desired pouring temperatures.

Mechanical properties are obviously affected by pouring temperature, Table 1. Optimum properties were obtained by pouring the keel block at 1950 F. Mechanical properties decreased as the pouring temperature increased above 1950 F. The bottom temperature level for keel blocks was indicated as having been reached when a keel block had to be poured from the top at 1850-1900 F in order to avoid a misrun. Properties of test specimens from the later keel blocks were 63,000 psi, tensile strength; 34,000 psi, yield strength; and 15.8 per cent elongation in 2 in.

The two 6 in. valve stems mounted to fit a 14 x 26 in. steel flask were poured through a common runner with a $1\frac{1}{4}$-in. diameter sprue and $\frac{3}{32}$ x 1 in. choke without difficulty as low as 2020 F. Three such molds were poured from one crucible beginning at 2150 F and ending at 2020 F. The total distance traveled by the metal before it finally came to rest was approximately 30 in. Aside from the fact that the choke slowed the pouring a little too much, no dfficulty was experienced in filling all corners of the mold cavity.

Eight, $4\frac{1}{4}$ x $12\frac{1}{4}$ x $\frac{7}{16}$-in. plates, were poured without misruns through a $\frac{3}{32}$ x 1 in. choke beginning at 2300 F. The total distance the metal traveled before coming to rest was approximately 24 in. In general, the pouring temperature range for this alloy seems to parallel closely the aluminum bronze family of alloys.

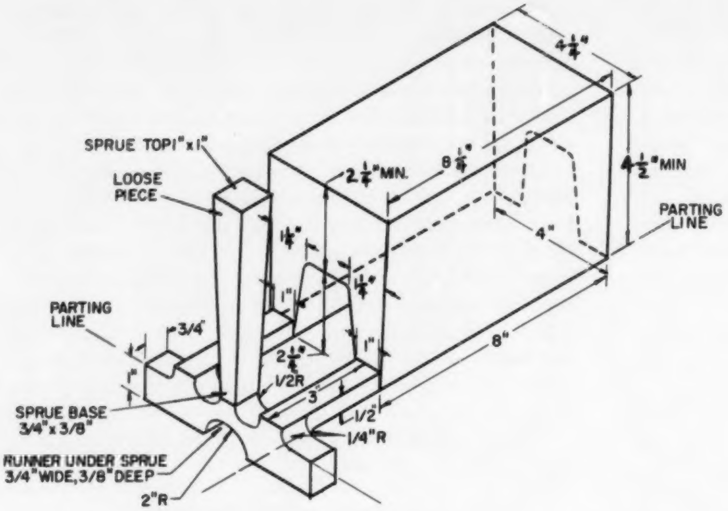


Fig. 1 — Double keel block test bar gated at the bottom.

GATING AND RISERING

Practices employed for manganese bronze and aluminum bronze apply to the new dezincification resistant alloy. This means large risers are required to accommodate shrinkage, and agitation in mold is to be avoided by inverted horn gate, or comparable techniques, bottom feeding the casting. About 50 per cent of a mold is gates and risers. It is good practice to gate into riser attached to heaviest section of casting so that hottest metal will be in riser, thus promoting directional solidification.

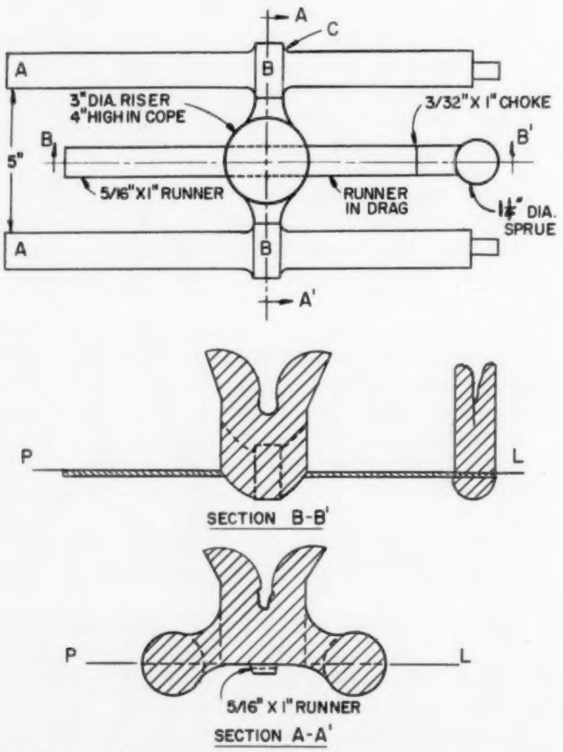


Fig. 2 — Rigging for 6 in. valve stem casting (heat 124).

Sections which cannot be reached by a riser may be chilled, if practicable. Chokes or screens may be used effectively in retaining dross in the sprue and a bypass in the runner (Fig. 2) serves to collect the dross which is formed during the first moments of the pour. Altogether the alloy presents no new problems in gating and risering. They have been encountered previously in production of manganese bronze and aluminum bronze castings.

SAND

The alloy performs well in all types of sand, e.g., natural bonded green sand, synthetic sands, synthetic oil sands, etc. Because the alloy contains aluminum and silicon, the castings shake out clean and bright. Best results have been obtained with sand having at least a 25 permeability, while with adequate venting sands with a 15 permeability can be tolerated.

PRODUCTION OF INTERNALLY SOUND 6 IN. VALVE STEMS

Most foundries prefer to gate valve stems at the threaded end. This is done to facilitate cutoff and grinding and to simplify gating to the extent that greater casting yields per mold are achieved. It is agreed that this is not the best procedure for maximum internal soundness because the laws of directional solidification are not followed. As shown in Fig. 7, nonrising cast valve stems have a collar about ⅔ the distance from the threaded end. The heavy collar section requires some other means than the riser at the threaded end to feed it. Depending upon the size of the stem, a chill around the collar and equal to the collar section eliminates centerline shrinkage at this point. However, as the length of the stem increases, the feeding distance of the riser at the threaded end becomes less effective and a secondary pipe in the stem at some intermediate distance is encountered.

In Tables 2 and 3, typical results of properties are given which can be expected from threaded end gating and risering without feeding or chilling the collar section, as shown in Fig. 7. The low elongation

TABLE 2 — CHEMICAL COMPOSITION OF COMMERCIAL VALVE STEMS

DESIGNATION			CHEMICAL COMPOSITION, %									
LAB. NO.	COMMERCIAL	A.S.T.M.	COPPER	TIN	LEAD	IRON	NICKEL	ZINC	PHOS.	MN	SILICON	ALUM.
119	NICKEL TIN BRONZE	B292-56,A	88.3	5.5	.27	.03	5.J	.85	.009			
120	SILICON BRASS	B198-52,13B	83.8		.05	.36	.05	11.9		.04	3.7	
122	SILICON BRASS	B98-58, D	95.2	.02	.27	.08	.05	.20		1.14	3.1	
123	MN BRONZE	B147-52,8A	59.6	.24	.23	.94	.12	37.4		.68	.03	.77

and tensile strength of the test bar (B) cut from the center of the collar section indicates lack of internal soundness in that area. While the test bar (A) cut from the threaded end has about 50 per cent greater tensile strength and yield strength and five times the elongation of test bar (B). This is undoubtedly attributed to the difference between a well fed and poorly fed section.

In either case, it is to be noted that the results are below A.S.T.M. minimums. This is not an alarming fact, since it has been proved many times that test bars cut from castings rarely, if ever, meet specifications, while from the same heat, test bars machined from accepted test bar designs will meet requirements. Apparently lack of strength in the core of the stem does not impair its serviceability. Design factors have compensated for the discrepancy between test bars and cast stems.

In spite of these accepted differences which have been lived with for years, and which have not been the cause for casting rejections, it was decided to see what had to be done to 6 in. valve stem castings to produce the same mechanical properties in the castings that are obtained in the test bar. As a starting point, four valve stems were taken from stock valves. From each stem a 0.505 in. tensile specimen was machined at the threaded end (A) and the collar section (B). The chemical compositions of these stems are shown in Table 2. The mechanical properties including A.S.T.M. minimum specifications are given in Table 3.

Sand Cast Valve Stems

Two of the commercial stems were sand cast. The upset bar stock stem (Lab. 122) was produced from half hard silicon bronze rod with the collar formed by an upsetting process. This produces a stem whose mechanical properties are enhanced by cold work. The chill cast stem (Lab. 123) was produced by pouring directly into the riser of a solid iron mold held vertically with the threaded end up. Properties of such castings are enhanced by the chilling effect of the iron mold.

Only the chemical requirements of Specification 9859 were met by Lab. 119 and 122. Only the end section (A) of Lab. 122 met mechanical property minimums. Only the end section (A) of Lab. 123 which did not meet chemicals passed the minumum mechanical requirements. The collar section (B) of Lab. 123 had a large shrink, and therefore no tensile test could be made.

Keeping in mind the requirements of the City of Los Angeles, none of these stems are acceptable, mechanically. Yet, these same specifications do not ask for said properties in the stem. They merely require that test bars be made for each heat of metal. Therefore, there is every reason to believe that had test bars been supplied with the four stems, all but one would have met the A.S.T.M. requirements for the alloy. Laboratory 119 specimen would not have responded to heat treatment because the lead content exceeds 0.01 per cent. However, as previously mentioned, none of the test bars except Lab. 122 would

TABLE 3 — MECHANICAL PROPERTIES OF COMMERCIAL VALVE STEMS

LAB. NO.	REMARKS	TEST BAR LOCATION IN STEM *	TENSILE STRENGTH, PSI	YIELD** STRENGTH, PSI	ELONGATION % IN 2"	REMARKS
119	SAND CAST	A	34,100	26,700	7.0	(NI VEE)
		B	33,900	26,800	6.0	
		A.S.T.M. MINIMUMS	75,000	50,000	5.0(H.T.)	***
120	SAND CAST	A	46,300	34,800	10.0	(TOMBASIL)
		B	31,100	24,200	2.0	
		A.S.T.M. MINIMUMS	60,000	24,000	16.0(A.C.)	
122	UPSET BAR STOCK	A	92,700	72,200	18.0	(EVERDUR)
		B	49,200	19,300	29.5	
		A.S.T.M. MINIMUMS	70,000	38,000	17.0 (H.H.)	
123	CHILL CAST	A	65,900		14.5	(MN BRONZE)
		B	NO TEST BECAUSE OF LARGE SHRINK AT CENTER OF REDUCED SECTION OF TEST BAR			
		A.S.T.M. MINIMUMS	65,000	25,000	20.0(AC)	

* SEE FIG.-2
** .005 IN/IN. EXTENSION UNDERLOAD
*** A.S.T.M. MINIMUMS BASED ON STANDARD PROCEDURES FOR TEST BARS

TABLE 4 — EFFECT OF DRY NITROGEN ON MECHANICAL PROPERTIES OF NEW ALLOY

HEAT NO.	POURING TEMP. °F	CONDITION	MECHANICAL PROPERTIES			
			TENSILE STRENGTH, PSI	YIELD STRENGTH, PSI *	ELONGATION, % IN 2"	BRINELL (500 Kg)
101-1	1970	WITHOUT DRY NITROGEN	55,200	36,200	11.0	78
101-3	1970	WITH DRY NITROGEN	69,500	37,700	29.6	90

* DIVIDER METHOD

have satisfied the City of Los Angeles on all mechanical requirements.

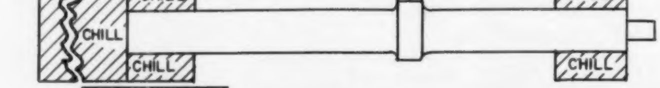
A study of the stem design indicated that a logical approach to directional solidification and consequently, internal soundness, would be to runner into a riser gated at the collar (Fig. 2). Foundries avoid gating into the collar because it makes the cutoff, grinding and machining operations difficult. This fact was recognized at the start of the program, but the gating practice had to be adopted because no other practical way of securing complete internal soundness could be devised. The first run with the matchplate gated, as in Fig. 2, was unsuccessful because a crack or shrink draw occurred at the junction of collar and stem (C, Fig. 2). The reason for this was that the junction was a sharp 90 degree angle. A fillet (3/8-in. radius) cured this, and results of subsequent tests are presented in Fig. 3.

Chills vs. No Chills

Heat 124 was prepared without the use of chills, while Heat 118 with variations in graphite chills shown in Fig. 3. The control specimen for each heat was poured to determine melt quality. Neither Heat 118-3 with 3 in. diameter x 6 in. solid end chills and chills 3 in. O.D. x 13/16-in. wall x 2 in. placed at both ends of the stem (Fig. 3), nor Heat 118-4 with 3 in. diameter x 3 in. solid end chills and chills 3 in. O.D. x 13/16-in. wall x 1½-in. were superior to Heat 118-5 which did away with the end chills and used only the 3 in. O.D. x 13/16-in. wall x 2 in. chills at both ends of the stem.

In other words, by using the gating system detailed in Figs. 2 and 3 in. O.D. x 13/16-in. wall x 2 in. graphite chills placed at (B) and (C) in Fig. 3, a 6 in. valve stem can be produced in cast this bronze which will meet the minimum requirements of Specification 8959 without heat treatment. As shown in the table (Fig. 3), properties such as those obtained in stems of this bronze exceed to a considerable extent the properties found in similar stems prepared with other commercial alloys (Table 3).

One pertinent point—the new dezincification resistant alloy was used in the gating system study. This does not imply that other materials would not have performed in a manner equal to the capabilities of their chemical composition. There is little doubt that had these materials been used with the gating technique in Fig. 2, values considerably higher than those reported to Table 3 for Lab. 119 and 120 would have been obtained.



HEAT NO.	CHILL DIMENSIONS a	b	c	d	TS. psi	Y.S. psi **	EL.% in 2"	REMARKS	POURING TEMP. °F
118-1*					66,000	31,000	30.6	CONTROL SPECIMEN	2,000
118-3A	6"	2"	2"	3"	68,000	35,000	26.8	THREADED END	2,150
118-3B					66,700	36,000	26.6	COLLAR SECTION	
118-4A	3"	1½"	1½"	3"	65,000	38,000	24.8	THREADED END	2,100
118-4B					65,000	30,000	22.0	COLLAR SECTION	
118-5A	NO	2"	2"	NO	67,000	38,000	24.6	THREADED END	2,050
118-5B	CHILL			CHILL	65,700	36,000	20.5	COLLAR SECTION	
124-1*					65,000	37,000	32.0	CONTROL SPECIMEN	2,000***
124-2A	NO CHILLS				53,000	42,000	7.7	THREADED END	2,050***
124-2B	NO CHILLS				65,000	36,000	19.0	COLLAR SECTION	

* STANDARD KEEL BLOCK (FIG. 1) ** DIVIDER METHOD *** ESTIMATED

Fig. 3 — Graphite chills effect on mechanical properties of new alloy 6 in. valve stem castings gated as in Fig. 2.

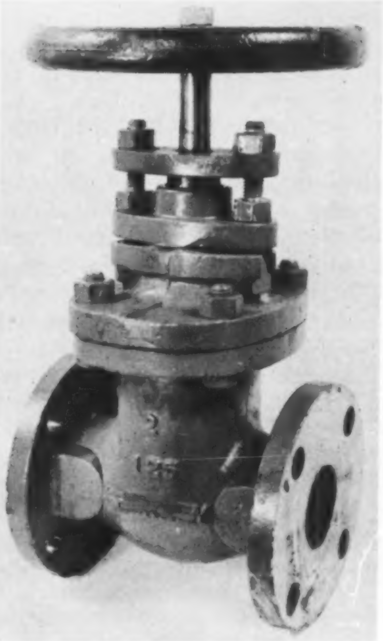


Fig. 4 — A 2 in. flanged valve with new alloy stem.

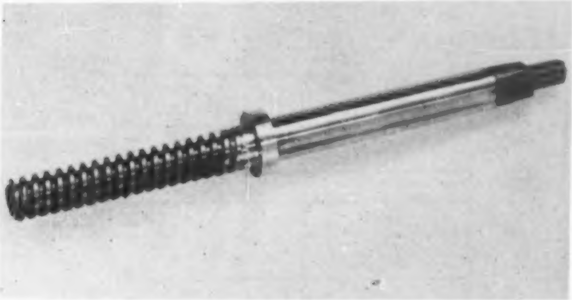


Fig. 5 — A stem of new alloy for 2 in. valve.

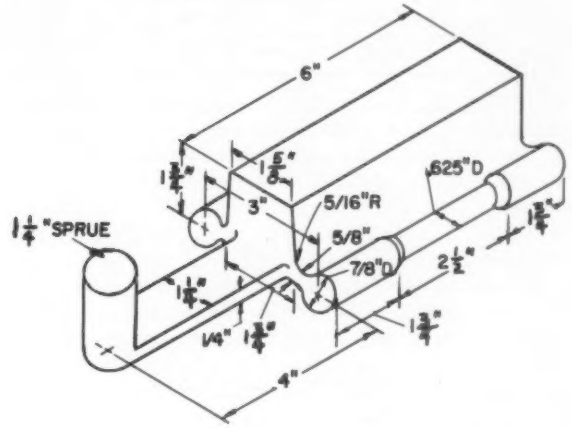


Fig. 6 — Modified Web-Webbert test bar.

CHEMICAL COMPOSITION

As previously mentioned, the alloy was developed to meet the chemical and mechanical requirements set forth by the City of Los Angeles in their Department of Water and Power Specification No. 8959 for Double Disc Gate Valves. This specification obviously was written around the work of Tabor[2] and Streicher,[1] with a view toward eliminating dezincification and dealuminumization. Bearing in mind the chemical limitations of the specification, the following composition was devised which would produce an alloy with minimum mechanical requirements of said specification. The chemical composition of the new alloy and the chemical limitations of Specification No. 8959 are:

Material	New Alloy, %	Specification 8959, %
Copper	80.00 to 88.00	
Nickel	1.00 to 5.50	
Iron	1.00 to 5.50	
Aluminum	0.50 to 2.00	2.00 (Max.)
Silicon	0.00 to 2.00	
Zinc	0.00 to 7.00	7.00 (Max.)
Others	0.00 to 2.00	

Others include such elements as tin, lead, manganese, phosphorous, antimony and magnesium. Judicious use of tin, lead and manganese impart slight improvements to corrosion resistance, machinability and yield strength, respectively, without adversely affecting tensile strength, elongation and hardness.

MECHANICAL PROPERTIES

The mechanical properties were established to satisfy structural and service demands of valve stems. It is assumed that the requirements were based on minimum mechanical properties of previously but unsuccessfully used materials because of lack of resistance to dezincification. Such alloys as silicon brass and manganese bronze come to mind as satisfying the tensile and elongation requirements (Table 3) of No. 8959 but fail to reach minimum yield strength, which has apparently been increased by the city of Los Angeles.

All tests were conducted with the standard keel block type of test bar (Fig. 1). Early in the development program a comparison was made between keel block and modified Web Webbert (Fig. 6) test bar properties. The results from tensile specimens cut from keel blocks were consistently superior, so this design was chosen as standard for the program. Since shrinkage characteristics of the alloy are similar to manganese bronze and aluminum bronze, it seems logical that the test bar design which suits these alloys would also suit an alloy with like characteristics.

Table 5 shows mechanical properties to which the alloy was developed in column No. 8959 as well as minimum, typical and range of this alloy's properties. The conclusion that all mechanical requirements are satisfied is obvious.

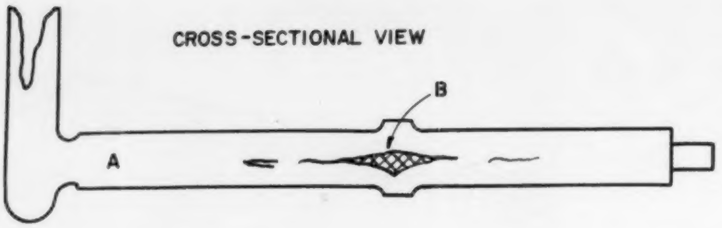


Fig. 7 — Valve stem gated at threaded end.

TABLE 5 — MECHANICAL PROPERTIES OF NEW BRONZE ALLOY

MECHANICAL PROPERTIES	SPECIFICATION NO.8959, MIN.	N D Z BRONZE		
		MIN.	TYPICAL	RANGE
TENSILE STRENGTH, psi	60,000	60,000	65,000	60,000-73,000
YIELD STRENGTH, psi	30,000	30,000	33,000	30,000-46,000
ELONGATION, % IN 2"	12	12	25	12 -40
BRINELL HARDNESS NO.(500 Kg)				78 -132

MACHINABILITY

It is an accepted fact that ratings for machinability are only relative. This new bronze alloy machines about as well as silicon brass. Although 80-10-10, 65,000 tensile strength manganese bronze and 85-5-5-5 are much more machinable, satisfactory machining can be accomplished with proper tooling, lubrication and reduced speeds.

CORROSION

As a result of the work of Tabor,[2] it was concluded that dezincification and dealuminumization could be prevented by limiting aluminum and zinc in bronze to 2 and 7 per cent, respectively. Therefore, it may also be concluded, with respect to the new dezincification resistant alloy, that it will not dezincify and/or dealuminumize since it conforms to Tabor's conclusions.

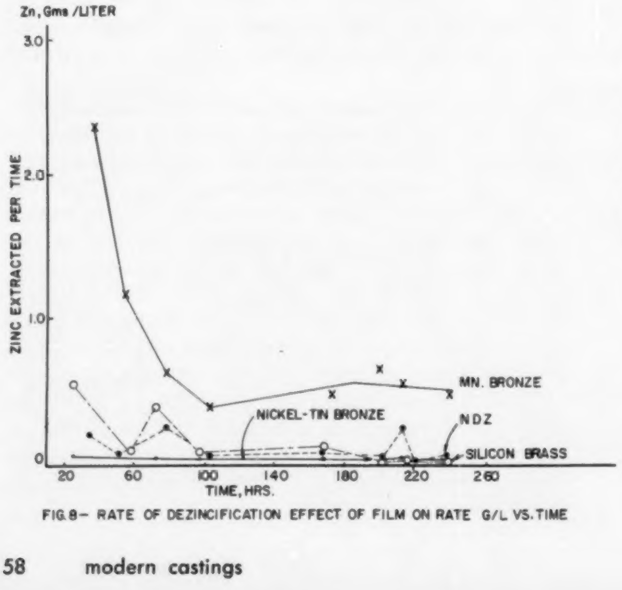


FIG.8— RATE OF DEZINCIFICATION EFFECT OF FILM ON RATE G/L VS. TIME

Acquisition of corrosion data at its best is most generally difficult, time consuming and frequently inconclusive. To get an idea of how the new material compared with the more widely used stem alloys, an accelerated dezincification test was devised by the author's company's chemical laboratory. The purpose of the accelerated test was to show the dezincification characteristics of established alloys versus experimental compositions. An essential prerequisite was to avoid specifically any influences that might be generated by coupling with any other metal. It is known that dezincification can be enhanced or suppressed, depending upon the variety of metal to metal contacts established in placing a valve into a plumbing installation.

The synthetic dezincification solution employed consisted of cupric chloride (5 per cent by weight) and of hydrochloric acid (one per cent by volume). Each specimen was suspended in 1000 ml of the above solution for a total of 240 hr. The temperature was thermostatically controlled between 95-100 C. The solution was vented to the atmosphere through a 32 in. air condenser. The specimen was suspended in the center of the flask with a $1/16$-in. diameter line.

Every 24 hr the specimen was removed, washed with hot water, dipped in acetone and dried at 105 C, weighed and its resistance determined with a Kelvin double bridge. Simultaneously, 25 ml of the synthetic dezincification solution was removed for analysis of zinc, copper and nickel. After completing the resistance measurements, the specimen and 25 ml fresh synthetic dezincification solution were returned to the flask.

By knowing the exact composition of the solution initially, the subsequent weight change of the specimen and a shift in the composition of the zinc, copper and nickel content of the solution, it was possible to determine what per cent of zinc, copper and nickel preferentially went into the solution above and beyond the incremental weight changes of the specimen. Thus, it became possible to predict expediently the tendency of any alloy to show dezincification. Also, because of the acute quantitive nature of this test procedure, it became possible to pin point

Fig. 8 — Corrosion curve.

minute differences in the tendency to dezincify in alloys that had previously been presumed to be comparable in their resistance to dezincification.

Previously established dezincification test methods have a tendency to be insensitive quantitatively and exceedingly prolonged in yielding reliable data. Thus, with this accelerated synthetic dezincification test it became possible to quickly evaluate comparative dezincification tendencies in a large number of experimental alloys that yielded desired mechanical properties. Ultimately, the compositions yielding optimum mechanical properties and resistance to dezincification were isolated.

Figure 8 shows how the new alloy lines up. Manganese bronze appears to corrode the fastest. Nickel-tin bronze, silicon brass and the new bronze alloy vary in their corrosion rates until about 220 hr has elapsed, at which time all alloys level off at about the same point.

There is, of course, no better evidence than that obtained by practical test. To this end the following is in progress:

1. Stems of the new alloy are in service in southwestern United States.
2. Immersion specimens and a 2 in. flanged valve are undergoing tests at Wrightsville Beach, North Carolina, by The International Nickel Co.
3. Corrosion cells are installed at Curtis Publishing Co., Philadelphia. This research will yield information on manganese bronze, Navy M, silicon brass, nickel-tin bronze and the new alloy.
4. Specimens are being subjected to tests described in the work of Tabor.[2]

ELECTRICAL CONDUCTIVITY

Per cent electrical conductivity of five materials for corrosion cell studies at Curtis Publishing Co. was determined prior to the corrosion test. The reason for this is that periodic determination of electrical conductivity as the cell test progresses are expected to indicate corrosion rate. At present, however, an interesting comparison of the electrical characteristics may be made (Table 6).

TABLE 6 — PERCENTAGE ELECTRICAL CONDUCTIVITY OF FIVE CASTING ALLOYS USED FOR VALVE STEMS

MATERIAL	%ELECTRICAL CONDUCTIVITY
MN BRONZE (65,000 psi)	17.76
NAVY "M"	14.92
SILICON BRASS	6.42
NICKEL-TIN BRONZE	12.08
NDZ	16.82

APPLICATIONS

The new bronze alloy was developed primarily to be used as a valve stem material (Figs. 4 and 5). Valve bodies and bonnets have also been produced. In view of the corrosion resistance and strength of the material, it would seem that it would be useful in other marine and corrosive applications, such as propeller wheels.

Electrical conductivity is surprisingly good. Coupled with high yield strength many applications come to mind requiring the combination of good electrical and mechanical properties.

CONCLUSIONS

A copper-base alloy which resists dezincification and dealuminumization has been developed. Typical mechanical properties are 65,000 psi tensile strength, 33,000 psi yield strength and 25 per cent elongation. The alloy, in addition to copper, contains iron, nickel, aluminum, silicon and zinc.

Foundry characteristics are similar to manganese bronze and/or aluminum bronze. Tensile specimens taken from commercial valve stems have mechanical properties which are, as expected, lower than the capabilities of the individual materials under test bar conditions. A properly gated, risered and chilled 6 in. valve stems will have same mechanical properties in the critical sections as those which are available in the alloy prepared under test bar conditions.

ACKNOWLEDGMENTS

The author wishes to thank the management of R. Lavin & Sons, Inc. for its interest in this project. Were it not for this, the development could not have been accomplished. A special mention is due Mr. Carl Morken, Vice Pres. & Works Mgr. of The Kennedy Valve Mfg. Co., Elmira, N.Y., who was instrumental in undertaking such a project, and who has extended full cooperation and contributed practical ideas as the research progressed. Mr. Floyd Keller, Head of Laboratories, and members of his staff are to be recognized for the accelerated corrosion testing and the many chemical and mechanical determinations required for the culmination of the alloy development program.

The Standard Casting Corp. of Chicago cooperated in preparing many of the heats necessary to determine the composition of the new alloy, and all the heats required to find proper gating and risering for internal soundness in 6 in. valve stem castings. The Iowa Valve Co. of Oskaloosa, and The Darling Valve & Mfg. Co. of Williamsport, Pa., who have subjected the alloy to foundry trials, and have been instrumental in getting corrosion tests performed, respectively.

REFERENCES

1. Lee Streicher, Jr., "Effects of Water Quality on Various Metals," *American Water Works Assn., vol. 48,* no. 3, p. 219 (March 1956).
2. Loring E. Tabor, "Effects of Softened Water on Equipment," *American Water Works Assn., vol. 48,* no. 3, p. 239 (March 1956).
3. American Water Works Association Gate Valve Standard, C500-59T.

DIE AND PERMANENT MOLD CASTING ALUMINUM ALLOY MINOR ELEMENTS

by D. L. Colwell and R. J. Kissling

ABSTRACT

The aluminum alloys used in die casting and permanent mold processes usually contain silicon or silicon and copper as alloying elements. There are other elements, beneficial and not, which are usually present in larger or smaller amounts. This report gives results of work done on different grades of these alloys, and the effects of some of these minor elements — namely, zinc, magnesium, iron and manganese.

INTRODUCTION

The common aluminum alloys used in the die casting and permanent mold processes usually contain silicon or silicon and copper as the most common alloying elements. There are several other elements however which are usually present in greater or lesser amount, some of which are beneficial, and others not beneficial. The purpose of this paper is to present some results of work done on various grades of these alloys and the effects of varying amounts of the four elements iron, zinc, magnesium and manganese.

In his Dudley Award paper for the American Society for Testing Materials, W. Bonsack has covered in great detail the effects not only of these four elements but of others less likely to be encountered.[1] Work done since this publication confirms the conclusions he drew, and it seems desirable at this time to summarize some of these confirmations.

IRON

Iron is always present in aluminum. In permanent mold castings superior mechanical properties, particularly elongation and impact strength, can be obtained when the iron content is low. In two popular permanent mold casting alloys, SG70A and SC51A, the American Society for Testing Materials specifies iron at maxima of 0.50 per cent and 0.6 per cent, respectively.[2] With the advent of higher purity aluminum, it has been found that with an iron content of about 0.10 to 0.15 per cent the elongation of these alloys is greatly improved.

By modification in heat treatment, higher yield strengths can be secured without losing elongation.[3] Consequently the high purity grades of these two alloys are being used in many instances. These high purity compositions have been recognized by A.S.T.M. in the addition of SG70B and SC51B showing iron maxima at 0.15 per cent.[2] Because of the higher purity of aluminum required these grades are somewhat more expensive, and care should be taken in their manufacture to use silicon of the lowest possible iron content.

In die casting alloys an iron content of around one per cent is highly desirable. When the pot metal alloys direct from the reduction cell were introduced to the die casting industry, they carried iron contents of 0.50 per cent or below, and an epidemic of soldering to dies and cores developed. Iron is now added to these pot metals, and the soldering difficulties are not nearly as prevalent as they were. Residual cryolite contents however are often continuing the soldering difficulty.

The principal effect of iron on the properties of the die casting is to increase hardness and decrease elongation and impact strength. This is illustrated in Fig. 1. The tensile strengths, elongation and Charpy impact strengths on four common die casting alloys with iron contents ranging from 0.75 to 2.05 per cent are plotted. S5C has a lower tensile strength and higher elongation than the other three, S12A, SC84A and SG100A, but the effect is the same.

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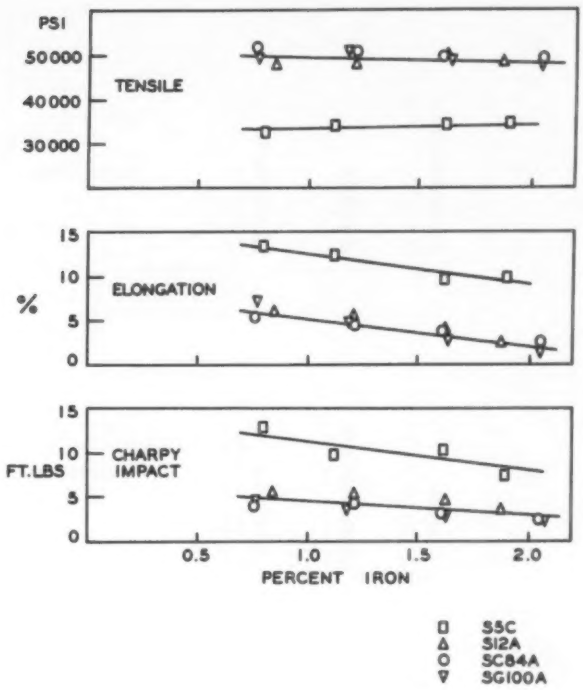

Fig. 1 — Iron effect on four die casting alloys aged one year at room temperature.

The values for the last three are plotted with one curve, but the individual points indicate that iron is somewhat more embrittling to SG100A and that SC84A has somewhat more tolerance for iron. These tests were made after one year of room temperature aging.

ZINC

The principal effect of zinc up to about 3 per cent in aluminum alloys containing copper and silicon is to improve machineability. Even in aluminum-silicon alloys such as S5C and S12A, a zinc content of about 0.5 per cent also helps machineability and has no harmful effects. A summary of the effect of zinc on several properties was presented before AFS in 1952[4] and similar conclusions were drawn by the British Non-Ferrous Metals Research Association.[5] The effect of zinc ranging from 0.4 to 2.0 per cent on CS43A alloy is shown in Table 1.

After one year of room temperature aging, the yield strength is somewhat higher with 2.0 per cent zinc, and there is almost no loss of elongation. In the T6 condition the yield strength is somewhat higher, and neither the tensile strength nor elongation is affected. The recent decision of the A.S.T.M. to increase the maximum zinc content of SC84A from one to 3 per cent was made after years of exhaustive testing. Under the control of Committee B6, test bars of this alloy with various zinc contents were exposed at two sites; one on the roof of the Port Authority Building in New York City, and the other 800 yards from the sea at Kure Beach, North Carolina. The results after 6 years exposure at these sites have just been released, and are summarized in Fig. 2.[6]

Each point on these curves is the average value of the tests of three laboratories on the bars made by

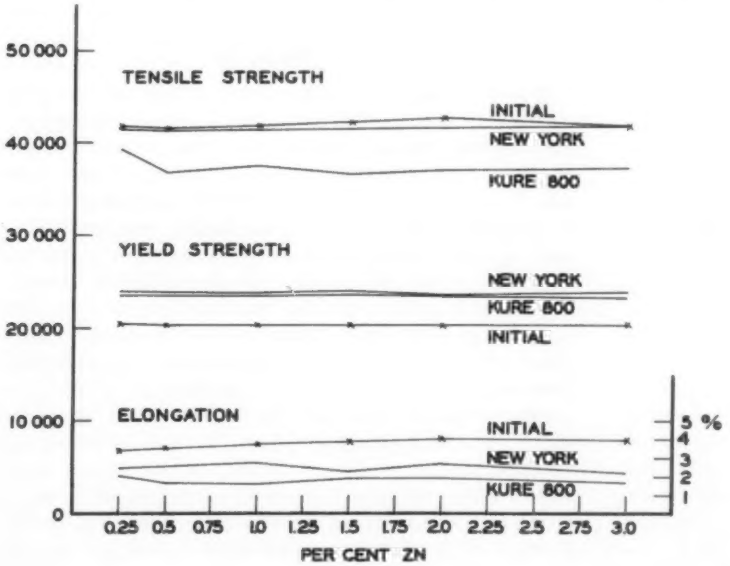

Fig. 2 — Die cast SC84A alloy with increasing zinc content after 6 years outdoor exposure at New York and at Kure Beach.

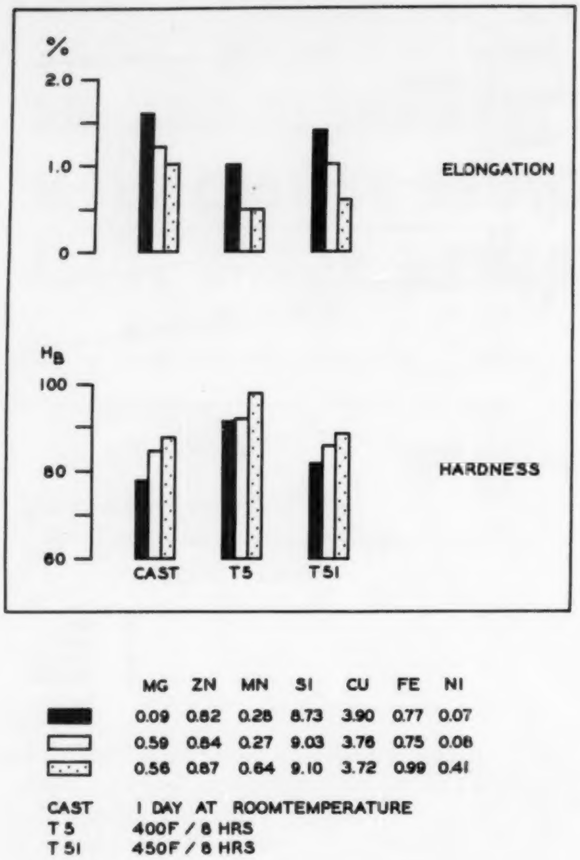

Fig. 3 — High magnesium and high magnesium plus manganese content effect on permanent mold cast SC84A alloy.

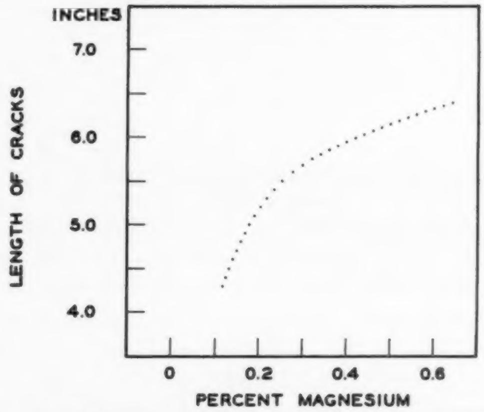

Fig. 4 — Magnesium effect on hot shortness of permanent mold cast SC64D alloy.[13]

three producers. There was some loss in tensile strength at the Kure Beach location, but the New York exposure indicated no effect on tensile strength. At both sites the yield strengths were higher and the elongations lower due to the aging of the alloy. The zinc contents, however, did not affect any changes due to the 6 years exposure, as the slope of the curves in every case parallels the curves of initial properties, and the 3 per cent zinc properties were equal to the 0.5 per cent zinc properties after 6 years. Even the expected severe corrosion of the Kure Beach location was no worse on the high zinc samples than on those with less zinc.

TABLE 1 — ZINC EFFECT ON PERMANENT MOLD CAST CS43A

	Zn, %	Yield Str., psi	Tensile Str., psi	Elong., %
Room				
One Year	0.4	22,500	33,100	1.8
	1.0	23,500	32,900	1.5
	1.5	22,900	35,400	1.6
	1.75	26,400	34,200	1.5
	2.0	25,600	32,400	1.4
T6	0.4	25,200	40,500	4.0
	1.0	25,900	39,900	3.7
	1.5	26,700	40,300	3.6
	1.75	27,000	40,200	3.7
	2.0	27,000	41,600	4.0

TABLE 2 — COMPOSITION OF DIE CAST SC84A TEST BARS FOR EFFECT OF MAGNESIUM

Composition, %						
Mg	Zn	Mn	Si	Cu	Fe	Ni
0.10	0.93	0.32	9.65	3.32	0.91	0.18
0.24	0.92	0.32	9.55	3.24	0.86	0.17
0.46	0.99	0.34	9.66	3.37	0.89	0.17
0.57	0.98	0.32	9.77	3.33	0.85	0.17

MAGNESIUM

Where magnesium is not required as an alloying element it is limited by most U. S. aluminum casting alloy specifications to 0.10 per cent maximum. In the two popular permanent mold casting alloys SC51A and B and SC70A and B, silicon and magnesium form magnesium silicide, and the solution and precipitation of this compound by heat treatments improves the mechanical properties. In the common silicon-copper casting alloys, the hardening effects of the magnesium silicide are harmful both from the standpoint of cold shortness (brittleness) and hot shortness (tendency to crack in the die or mold).

Magnesium should be held to low limits in these alloys. Fortunately magnesium can be removed so there is no excuse for requesting higher limits than about 0.15 per cent. The hardening effects of magnesium in a permanent mold casting alloy containing 4 per cent copper and 9 per cent silicon are shown

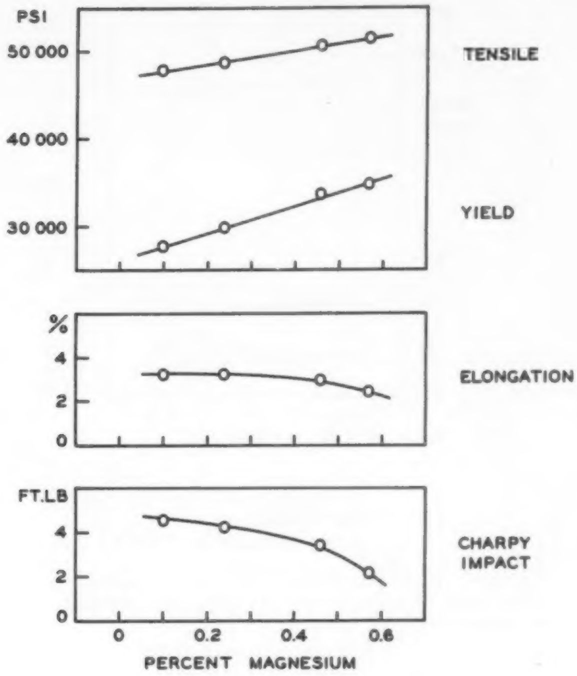

Fig. 5 — Magnesium effect on die cast SC84A alloy aged 6 months at room temperature.

in Fig. 3. The T5 and T51 properties are approximately those that would be typical after a few years service. The 50 per cent loss of elongation in the T5 condition is particularly important where this property is already at a low value.

Similar results are reported by Martin,[7] Quadt and Davis,[8] Scheuer[9] and B.N.F.M.R.A.[10] British specification DTD424[11] covering an alloy similar to the A.S.T.M. SC64D has a magnesium maximum of 0.15 per cent but recommends that the magnesium be kept below 0.10 per cent if optimum results are to be obtained. Gittins and Mew[12] have studied the effect of magnesium in combination with copper on LM4 alloy (5.8 per cent silicon) cast in sand. With no copper the magnesium can be as high as 0.40 per cent and with 4 per cent copper there should be no magnesium at all to obtain a minimum of 2 per cent elongation.

Bertram et al[13] found that 0.6 per cent magnesium reduced the elongation of chill cast SC64D alloy from 2 to one per cent. They also present an interesting study of the effect of magnesium on the hot shortness of this alloy. An increase in magnesium from about 0.1 to 0.6 per cent increases the hot shortness cracks in their test approximately one half. This is illustrated in Fig. 4. In the die casting alloy SC84A, magnesium up to 0.6 per cent gradually increases the tensile strength and yield strength and reduces the elongation and Charpy impact strength.

The compositions tested are shown in Table 2, and the relative values after 6 months room temperature aging are shown in Fig. 5. The drop in Charpy impact strength from 4.5 ft-lb at 0.10 per cent magnesium to 2.2 ft-lb at 0.57 per cent magnesium illustrates the harmful embrittling effect of magnesium. Conversely it should be pointed out that in alloys such as ZG32A and GM70B where magnesium is used for its strengthening properties, silicon is a harmful impurity and should be kept below 0.20 per cent. These represent the high strength casting alloys where heat treatment is unnecessary, and silicon in these alloys has the same harmful effect as magnesium does in the aluminum-silicon-copper-alloys.

MANGANESE

Manganese in small quantities is usually considered a desirable addition to both die casting and permanent mold aluminum alloys, whereas in larger quantities it has a hardening and embrittling effect. In the permanent mold casting alloy SC51 for example, the A.S.T.M. recommends a manganese content in an amount equal to one half the iron if the iron content exceeds 0.45 per cent.[2] It is a desirable addition to the high strength alloys ZG32A and ZG42A, and is used to improve the high temperature strength in the piston alloys SC122A and CS66A. In most other alloys the acceptable maximum is 0.50 per cent.

Above this amount it increases hardness and decreases ductility and is likely to give trouble in casting. The dotted right hand bars in Fig. 3 indicate how a manganese content of 0.64 per cent lowers the elongation and increases the hardness of a chill cast alloy which is already hard and brittle.

The smaller quantities of manganese are of value in changing the iron-aluminum complex from a harmful needle or plate type structure into a complex iron-manganese-aluminum which minimizes the harmful effect of the iron. The reduction in elongation and impact strength with increasing iron content shown in Fig. 1 would probably have been much greater had it not been for the presence of manganese.

Manganese is almost a necessity in aluminum die casting alloys up to about 0.40 per cent as the manganese-iron combination greatly reduces the tendency of an aluminum alloy to solder. One of the great difficulties with the pot metal type of alloy being offered to the die casting industry is in soldering, and one of the reasons for soldering is the low iron and manganese usually in these alloys.

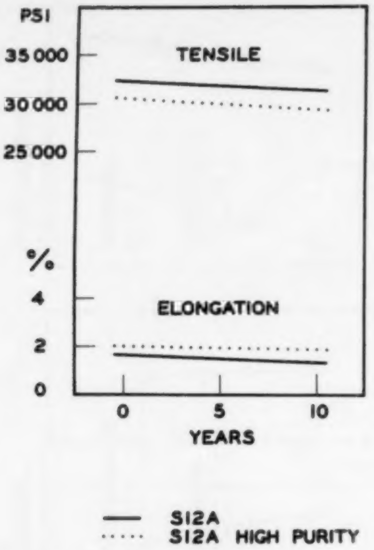

Fig. 6 — Tensile properties of die cast commercial and high purity S12A alloy after 10 years outdoor exposure at three sites.[15]

HIGH PURITY ALLOYS

Although the heat treated properties of the high purity grades SC51B and SG70B discussed above are due to low iron content, die casting alloys seem to be improved by the impurities allowed by the specifications of the A.S.T.M. Committee B6 of the A.S.T.M.[14] initiated a cooperative exposure test on S12A back in 1934. Bars made by several producers were exposed at Sandy Hook, New York City and Altoona, Pa., and the results after 10 years exposure were summarized by the author in 1950.[15] The two compositions tested are shown in Table 3, and the average of the changes in mechanical properties at all three sites is shown in Fig. 6. The depth of corrosion attack after 10 years is shown in Fig. 7. Committee B6 drew the conclusion that after 10 years exposure both alloys exhibited "a high resistance to corrosion" and that "there were no really significant differences."[16]

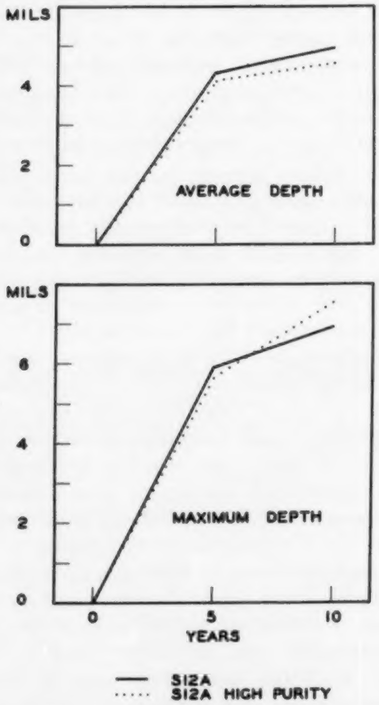

Fig. 7 — Depth of corrosion attack on die cast commercial and high purity S12A alloy after 10 years outdoor exposure at three sites.[15]

TABLE 3 — COMPOSITION OF COMMERCIAL AND HIGH PURITY GRADES OF S12A TEST BARS FOR A.S.T.M. TEN YEARS OUTDOOR EXPOSURE TEST[15]

Composition, %	Commercial Purity	High Purity
Mg	0.055	0.005
Zn	0.52	0.00
Mn	0.26	0.01
Si	12.14	11.94
Cu	0.42	0.09
Fe	1.44	1.20
Ni	0.32	0.01

A similar test on alloy SG100A was initiated by Committee B6 in 1943 with similar results.[17] The two compositions tested are shown in Table 4, the effect of outdoor exposure for 10 years at the three sites in Fig. 8 and the effects of one year exposure in 20 per cent salt spray are shown in Fig. 9. The high purity grade has a slightly lower tensile strength and a higher elongation than the commercial grade. The nominal compositions of the alloys, and A.S.T.M. designations, are given in Table 5.

The atmospheric exposure shows a degree of age hardening for the first two years and then a flattening out of properties. The salt spray exposure shows a little faster deterioration of tensile strength in the commercial grade, and a little faster deterioration of elongation in the high purity grade. Generally speaking the properties of the commercial grade are equal to those of the high purity grades, and certainly the castability of the commercial grade is superior.

TABLE 4 — COMPOSITION OF COMMERCIAL AND HIGH PURITY GRADES OF SG100A TEST BARS FOR A.S.T.M. TEN YEAR OUTDOOR EXPOSURE TEST[17]

Composition, %	Commercial Purity	High Purity
Mg	0.54	0.54
Zn	0.006	0.00
Mn	0.01	0.005
Si	9.72	9.61
Cu	0.20	0.04
Fe	1.11	0.30
Ni	0.01	0.01

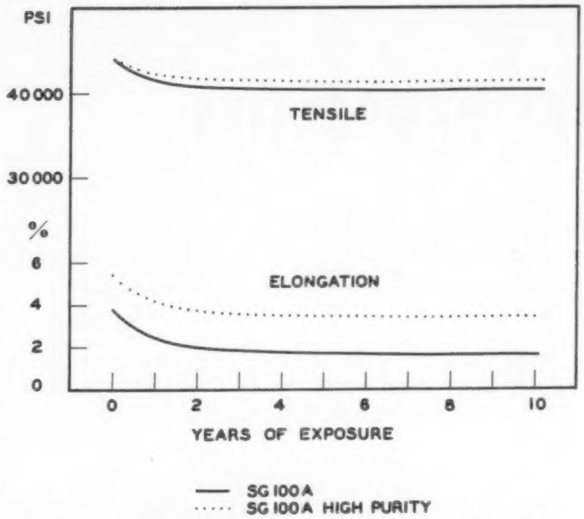

Fig. 8 — Ten years outdoor exposure at two sites effect on die cast commercial and high purity SG100A alloy.[17]

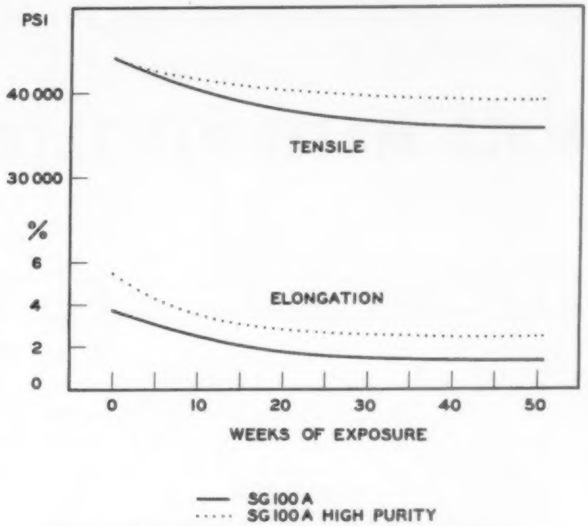

Fig. 9 — One year exposure to 20 per cent salt spray effect on die cast commercial and high purity SG100A alloy.[17]

CONCLUSIONS

It is believed that the following conclusions are justified:

1. Except in exceptional applications the limits on minor elements specified by the A.S.T.M. will prove entirely satisfactory.
2. Iron has a hardening effect decreasing elongations, and particularly in certain permanent mold alloys it should be held low. In die casting alloys castability is improved up to one per cent or a little more, and beyond this embrittlement, particularly in SG100A, occurs.
3. Zinc up to the limits specified by the A.S.T.M. is valuable for improved machineability and has no harmful effects.
4. Magnesium in amounts greater than about 0.10 per cent is harmful both to castability and to the mechanical properties obtained. This element can be removed, and there is no sound reason for higher allowances.
5. Manganese is usually a desirable element up to about ½ of the iron content. It breaks up the iron needles and helps both castability and mechanical properties, particularly at high temperatures. Its use above the A.S.T.M. limits of 0.50 per cent cannot be justified, except in special cases such as in piston alloys where the effect on the coefficient of expansion is favorable.

TABLE 5 — ALLOY DESIGNATIONS

A.S.T.M. Designation	Nominal Composition, % Cu	Si	Mn	Mg	Zn	Cr
CS 43A	4.0	3.0				
CS 66A	6.5	5.5		0.4		
GM70B			0.2	7.0		
S5C		5.0				
S12A		12.0				
SC51A	1.2	5.0		0.5		
SC51B	1.2	5.0		0.5		
SC64D	4.0	6.0				
SC84D	3.5	8.5				
SC122A	1.5	12.0	0.7	0.7		
SG70A		7.0		0.3		
SG70B		7.0		0.3		
SG100A		9.5		0.5		
ZG 32A			0.5	1.7	3.0	0.3
ZG 42A			0.5	2.1	4.2	0.3

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MOLD MATERIALS THERMAL PROPERTIES

by M. R. Seshadri and A. Ramachandran

ABSTRACT

Thermal properties of new mold materials can be determined with ease by an unsteady state method involving melting and casting. Results of the present investigation reveal that (1) in general heat diffusivity values of mold materials bonded by CO_2 process will be higher compared to bentonite bonded, (2) among nonmetallic mold materials investigated, silicon carbide (CO_2) has the maximum heat diffusivity and synthetic sand the minimum and (3) solidification time of test castings calculated from the thermal properties of mold materials evaluated by the unsteady state method compares favorably with those of experimentally determined values.

INTRODUCTION

In recent years attention has been directed towards the scientific aspects of the production of quality castings. The casting quality is dependent upon a number of variables, such as the nature of metal or alloy cast, properties of the mold material employed and the casting technique. However, the thermal properties of the mold materials, as reported by earlier investigators, will determine to a large extent the rate of heat extraction for a given casting and thus influence its quality.

There have been several investigations in the past few years on the evaluation of thermal properties of mold materials by different methods. Of the several methods available for the determination of the thermal characteristics of the mold materials, the unsteady state method of evaluating thermal properties, involving melting and casting has attracted much attention. However, a literature survey indicates that limited data are available on the thermal characteristics of various mold materials bonded with sodium silicate, i.e., CO_2 process. Moreover, no data are available on indigenous mold materials bonded with bentonite. Hence experiments were conducted to determine the thermal properties of mold materials bonded with bentonite and sodium silicate, i.e., CO_2 process.

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PREVIOUS WORK

Rapid developments have taken place recently in measurement of thermal properties of mold materials. The several methods adopted can be classified:

1) Steady state method for conductivity and temperature diffusivity.[1,2,3,4]
2) Unsteady state methods:
   a. Line or plane heat source for conductivity and temperature diffusivity.[5,6]
   b. Involving making of a casting for temperature diffusivity, conductivity and heat diffusivity.[7,8,9,10,11,12,13,14]
3) Methods of calculation for conductivity, temperature diffusivity and heat diffusivity.[14]

Measurements of the thermal conductivity of clay free sand, molding sand and several other molding materials including zircon, plaster and fired exothermic materials over a wide range of temperatures have been made by Atterton[1] using a steady state method. Effects of temperature, grain size and ramming density on thermal conductivity of mold materials, were also investigated by him. Care must however be taken that a correct mean value is used in applying Atterton's data to solidification problems.

Evaluation of thermal constants by unsteady state methods involving melting and casting have been reported by many workers. Ruddle,[8] Ohira,[9] Halbart,[10] Abcouver,[11] Briggs and Locke,[12] Adams and Taylor,[13] and Berry, Kondic and Martin[14] have determined the thermal properties of various mold materials by the unsteady state method, involving melting and pouring of metal or alloy into molds. Ruddle,[8] who has determined the mean temperature diffusivity for the following mold materials—(a) fine silica sand (Erith) dry state, (b) naturally bonded sand (Mansfield) in dry state, (c) silicon carbide grit (bonded) and (d) magnesite bonded (dead burnt powder)—has adopted Chvorinov's[7] method for evaluating the mean temperature diffusivity. Taylor[13] in his paper has stated that the thermal properties of mold materials must be determined under casting conditions in order to be useful for solidification studies.

The previous work, however, indicates that not much of data are available about the thermal prop-

TABLE 1A

Mold Material	Grading, % retained on B.S. Sieve No.							Remarks
	−30+44	−44+60	−60+100	−100+150	−150+200	−200+300	Pan	
Silica Sand	11.4	39.0	40.2	9.4	—	—	—	Pale white in color composed mostly of sub-angular grains.
Magnesite	11.00	30.50	39.60	11.20	7.40	—	—	Brownish red in color. Angular and sub-angular grains.
Silicon Carbide	—	—	—	6.8	23.0	48.6	21.6	Slate gray in color mostly angular particles.

erties of mold materials used in CO_2 process. Also, no data are available about indigenous mold materials bonded with bentonite employed in local foundries.

EXPERIMENTAL PROCEDURE

High purity aluminum and aluminum-12 per cent silicon alloys (unmodified) were used as test casting for evaluating the thermal properties of nonmetallic mold materials by the unsteady state method involving melting and casting. The test casting, cylindrical in shape was 8 cm in diameter and 16 cm long.

Molding

Nonmetallic mold materials, such as silica sand, magnesite and silicon carbide, the gradings of which are shown in Table 1A, were used for preparing bentonite bonded and CO_2 molds. Properties of the molds thus prepared and the treatments given to them are listed in Table 1B.

TABLE 1B — MOLD DETAILS

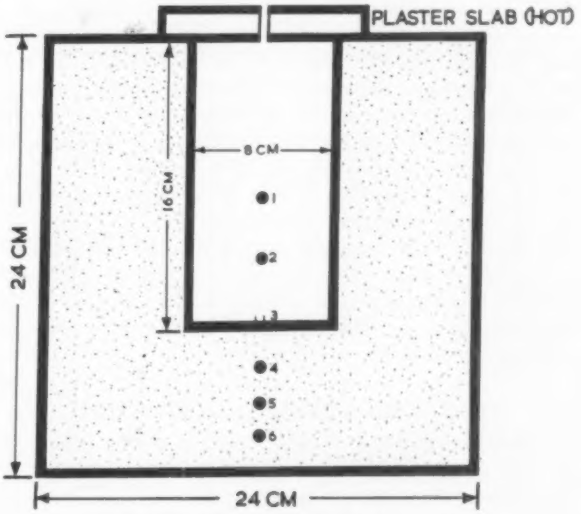
Mold Material	Bond, %	Moisture content, %	Baking treatment hr	Baking treatment C (F)	Density, gm/cc (dry)
Silica Sand	5 (Bentonite)	4	8	200 (392)	1.46
Silica Sand	3 (Sodium Silicate)†	2	8	200 (392)	1.54
Magnesite	5 (Bentonite)	4	8	200 (392)	1.60
Magnesite	3 (Sodium Silicate)	2	8	200 (392)	1.69
Silicon Carbide	5 (Bentonite)	4	12	200 (392)	1.65
Silicon Carbide	6 (Sodium Silicate)†	2	12	200 (392)	1.74

† Molds hardened by CO_2 process.

Molds were prepared using cylindrical molding boxes 24 cm in diameter and 24 cm long, having a number of vent holes on the periphery. In all the experiments, molds were hand rammed with necessary precautions by the same operator. Chromel-alumel thermocouples were placed in the mold at predetermined locations, as shown in Fig. 1. Due care was taken to minimize the shifting of the thermocouple during ramming. The actual positions of the thermocouples in the mold were determined by carefully scraping the mold material at the end of the experiment. The interface thermocouple was fixed in the manner used by Atterton and Houseman.[15] Twenty-six chromel-alumel thermocouples, sheathed in twin bore oval section 3 x 1.5 mm unglazed porcelain sleeves, were inserted from the top through the central hole of the plaster slab into the mold cavity for recording the metal temperature.

Melting and Pouring

Normal melting and degassing procedures were adopted for melting high purity aluminum and aluminum-12 per cent silicon alloy (unmodified). Melting was carried out in a forced draught coke fired pit furnace. Casting temperature was 700 C (1292 F), and in all the experiments the metal was not allowed to exceed a temperature of 770-780 C (1418-1436 F) in the furnace.



THERMOCOUPLE POSITIONS

1. 80 MM FROM CASTING INTERFACE.
2. 40 MM FROM CASTING INTERFACE.
3. CASTING INTERFACE (ATTERTON TECHNIQUE)
4. 8 MM FROM MOULD INTERFACE.
5. 20 MM FROM MOULD INTERFACE.
6. 33 MM FROM MOULD INTERFACE.

Fig. 1 — Thermocouple position in mold.

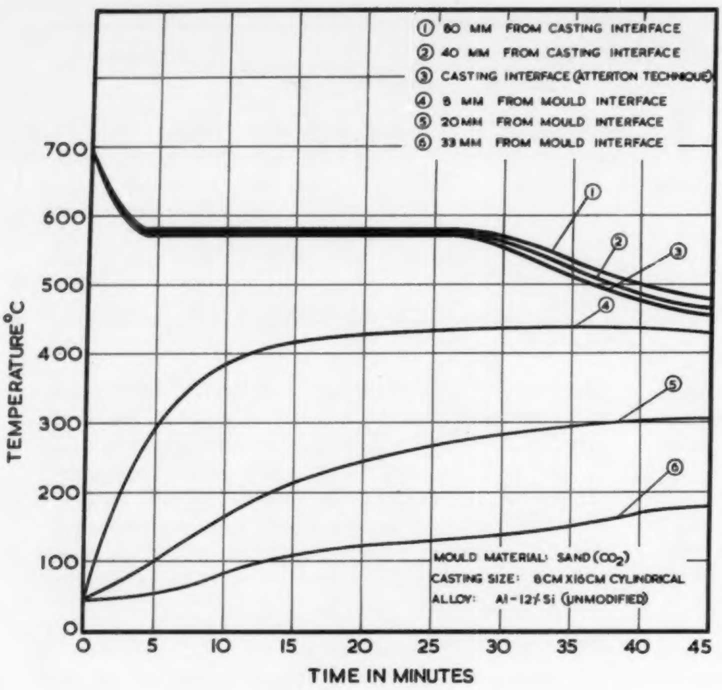


Fig. 2 — Cooling and heating curves on the casting and mold side during solidification of Al-12 per cent Si alloy (unmodified).

While pouring the metal into the molds due care was taken to minimize turbulence. As soon as the mold cavity was filled up with molten metal, a plaster slab was placed covering the top surface of the metal and the mold to minimize the heat loss from the top surface.

Thermal Analysis

Cooling and heating curves on the metal and mold side during solidification were recorded with the aid of a six point high speed recorder having a full scale response time of 2.0 sec. Figure 2 shows as an example the cooling and heating curves thus obtained during the solidification of Aluminum-12 per cent silicon alloy (unmodified) cast in a CO_2 sand mold. Experiments were also conducted with a 6.5 cm diameter by 13 cm long test casting instead of 8 cm x 16 cm cylindrical casting, in order to gain some information on the effect of casting size on the value of the temperature diffusivity, α_2 determined by the unsteady state method.

TEST RESULTS AND DISCUSSION

The time-temperature distribution curves obtained on the mold side in various molds, during the solidification of high purity aluminum and aluminum-12 per cent silicon test castings, were analysed for the determination of the temperature diffusivity.

Temperature Diffusivity (α_2)

If the plane boundary of a semi-infinite solid body initially at a uniform temperature θ_o is instantaneously raised to a temperature θ_1 at time $t = 0$, then after a time t the temperature θ_m at any point whose perpendicular distance from the boundary is x, is given by

$$\theta_m = \theta_o + (\theta_1 - \theta_o)\,\mathrm{erfc}\,\frac{x}{2\sqrt{\alpha_2 t}} \qquad (1)$$

Where

θ_m = the temperature in C at a point in the solid whose perpendicular distance from the interface is x.
θ_o = Ambient temperature C.
θ_1 = Interface temperature in C.
x = Distance from interface, in cm.
α_2 = Temperature diffusivity of mold material.
t = time lapsed, in sec.

$\mathrm{erfc}\,\frac{x}{2\sqrt{\alpha_2 t}} = 1 - \mathrm{erf}\,\frac{x}{2\sqrt{\alpha_2 t}}$ and $\mathrm{erf}\,\frac{x}{2\sqrt{\alpha_2 t}}$ is the error function defined by

$$\mathrm{erf}\frac{x}{2\sqrt{\alpha_2 t}} = \frac{2}{\sqrt{\pi}}\int_0^{\frac{x}{2\sqrt{\alpha_2 t}}} e^{-\beta^2}\, d\beta$$

This equation can be applied to mold walls of low conductivity with little error,[15] despite the assumption that the mold wall is semi-infinite and thus permits evaluation of thermal properties of molding materials. However, for calculating the value of α_2 one should know the correct value of θ_1, i.e., the mold metal interface temperature. Several investigators have tried to measure θ_1 experimentally or calculate the interface temperature from other data available. One can easily measure the casting skin temperature by the Atterton and Houseman technique whereas the measurement of mold-metal interface temperature offers considerable practical difficulties.

Reimann[16] and Halbart[10] have suggested a simple method of calculating the interface temperature provided we know the thermal diffusivities b_1 and b_2

of the metal and the mold material. Recently Berry, Kondic and Martin[14] have suggested a modification in this method of calculating the interface temperature, and this has been shown to be nearer the experimentally determined values.

According to Reimann[16] interface temperature θ_i is given by

$$\theta_i = \frac{b_1\,\theta_1 + b_2\,\theta_2}{b_1 + b_2} \tag{2}$$

Berry et al[14] have suggested a modification of equation (2). The interface temperature $\overline{\theta_i}$ according to them is given by

$$\overline{\theta_i} = \frac{b_1'\,\overline{\theta_1} + b_2\,\theta_2}{b_1' + b_2} \tag{3}$$

where

$\overline{\theta_1}$ = weighted mean value of temperature.

$b_1' = k_1\,\overline{\rho_1}\left(C_1 + \frac{L_1}{\theta_s}\right)$ where θ_s = solidification temperature.

In the present investigation interface temperature were calculated using equations (2) and (3), and are shown in Table 2 for ease of comparison. From this table one can conclude that the calculation of interface temperature by Berry et al[14] method is nearer to the experimentally determined values. Hence in this investigation for evaluation of temperature diffusivity from equation (1), interface temperature, i.e., $\overline{\theta_i}$ was used.

In Fig. 3 is shown the plot of θ_m against $\frac{x}{\sqrt{1.33t}}$ for CO_2 molding sand. A close agreement between the theoretical curve represented by an equation of the form $\theta_m = 30 + (571 - 30)\ \mathrm{erfc}\ \frac{x}{\sqrt{3 \times 0.0009}}$ and the experimental points can be seen in Fig. 3.

In Table 3 are listed the temperature diffusivities thus determined for various mold materials with aluminum and aluminum-12 per cent silicon unmodified as test castings.

Apparent Thermal Conductivity (κ_2)

From the specific heat data available in the literature, and the density and temperature diffusivity values experimentally determined, apparent thermal conductivity of various molding materials examined

TABLE 2 — TEST CASTING — HIGH PURITY ALUMINUM

Poured at 700 C (1292 F)	Solidification range, 659-650 C (1218-1202 F)	
	Interface temperature (Calculated) C (F)	
Mold Material	Reimann Eq. (2)	Berry, Kondic and Martin Eq. (3)
Synthetic sand, dry	667 (1233)	647 (1197)
Sand, CO_2	658 (1216)	644 (1191)
Magnesite, bonded	655 (1211)	640 (1184)
Magnesite, CO_2	654 (1209)	639 (1182)
Silicon Carbide, bonded	650 (1202)	636 (1177)
Silicon Carbide, CO_2	647 (1977)	634 (1173)

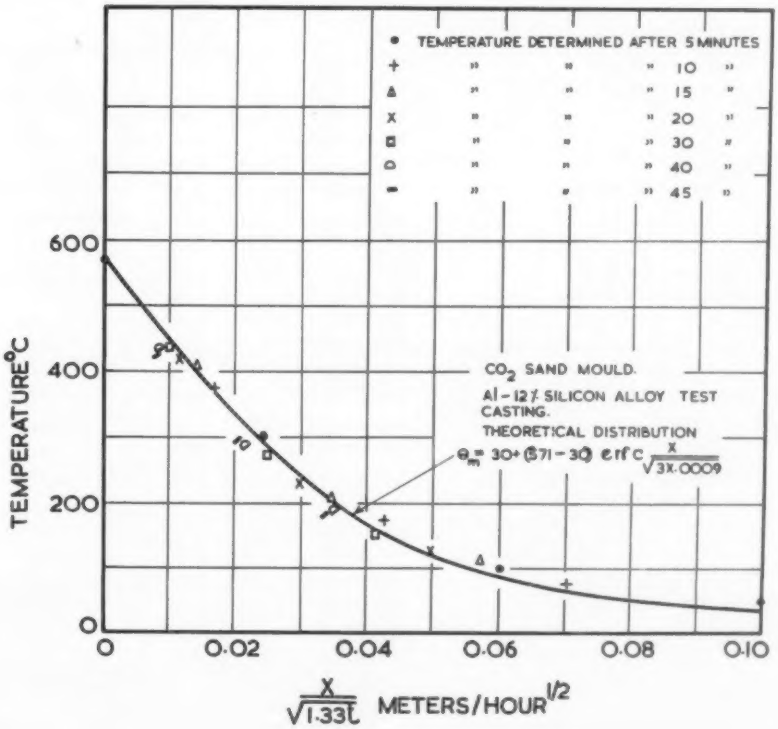


Fig. 3 — θ_m vs. $\frac{x}{(1.33\,t)^{0.5}}$.

were calculated. In column 5 of Table 3 are listed the apparent thermal conductivity values of various molding materials thus calculated corresponding to the temperature range 30 C (86 F) to 574 C (1065 F) and 30 C (86 F) to 650 C (1202 F).

Heat Diffusivity (b_2)

In column 6 of Table 3 are listed the heat diffusivity values calculated for various molding materials at two interface temperatures namely 574 C (1065 F) and 650 C (1202 F). It can be seen from this table that the heat diffusivity values of mold materials prepared by CO_2 process are higher compared to those bonded with bentonite. Silicon carbide (CO_2) has the maximum heat diffusivity among the nonmetallic mold materials studied.

Effect of Temperature on K_2, α_2 *and* b_2

As reported by earlier investigators,[15] sand and silicon carbide either bonded with bentonite or by CO_2 process show an increase in thermal conductivity or heat diffusivity with the increase in interface temperature. Although in the literature magnesite is reported to have higher heat diffusivity compared to silicon carbide at aluminum and its alloy casting temperatures, it is found to have a lower value since the magnesite employed in this investigation is of a lower grade, as indicated by physical and chemical tests carried out in the laboratory. However, the decrease in thermal conductivity of magnesite with the increase in interface temperature as observed by some investigators in this field was found to hold good partly in this magnesite sample also.

Test Casting Size Effect

From Table 3 one can also infer that on reducing the size of the test casting from 8 cm diameter x 16 cm long to 6.5 cm diameter x 13 cm long, the value of α_2 obtained for a given mold material will remain unaltered. Probably further decreasing the test casting dimensions may result in a different value of α_2 for the same mold material due to corner effects.

Mold Constant (ξ)

The quantity ξ, often referred to as the mold constant, controls the rate at which the mold absorbs heat. It is a direct measure of the chilling power of the mold. Mold constant values for various molding materials calculated using the equation $Q = 1.128\, b_2 (\theta_1 - \theta_o) \sqrt{t}$ are listed in the last column of Table 3.

Total Heat Extracted and the Rate of Heat Extraction

In Figs. 4, 5, 6 and 7 are shown the curves obtained by plotting the total heat extracted, Q and the rate of heat extraction, dQ/dt from mold surface of various mold materials against time for two interface temperatures. From Figs. 4 and 6 it can be seen that the heat extracted by the silicon carbide or magnesite

TABLE 3

Mold Material	Temperature range 30 C (86 F) room temperature to C (F)	Mean specific heat (cgs) Cal/gm C	Experimentally determined mean temp. diffusivity (cgs) cm²/sec	Calculated mean apparent thermal conductivity (cgs) cal/cm sec C	Calculated mean heat diffusivity (cgs)	Calculated mold constant cal/cm²/min½
Synthetic sand, dry (density = 1.46 gm/cc)	574 (1065) [a]	0.248	0.0019	0.0007	0.016	76.3
	574 (1065) [b]	0.248	0.0019	0.0007	0.016	76.3
	650 (1202) [a]	0.25	0.0022	0.0008	0.017	92.2
	650 (1202) [b]	0.25	0.0025	0.0009	0.018	97.5
Sand, CO_2 (density = 1.54 gm/cc)	574 (1065) [a]	0.248	0.0025	0.00095	0.019	90.5
	574 (1065) [b]	0.248	0.0025	0.00095	0.019	90.5
	650 (1202) [a]	0.25	0.0028	0.0010	0.020	108.5
	650 (1202) [b]	0.25	0.0028	0.0010	0.020	108.5
Magnesite, bonded (density = 1.60 gm/cc)	574 (1065) [a]	0.26	0.0034	0.0014	0.024	114.2
	574 (1065) [b]	0.26	0.0035	0.00145	0.024	117.4
	650 (1202) [a]	0.263	0.0031	0.0013	0.023	124.9
	650 (1202) [b]	0.263	0.0034	0.0014	0.024	130.1
Magnesite, CO_2 (density = 1.69 gm/cc)	574 (1065) [a]	0.26	0.0036	0.0016	0.0253	123.0
	574 (1065) [b]	0.26	0.00364	0.0016	0.0258	123.0
	650 (1202) [a]	0.263	0.0031	0.0014	0.0248	134.2
	650 (1202) [b]	0.263	0.0034	0.0015	0.0259	140.5
Silicon carbide, bonded (density = 1.65 gm/cc)	574 (1065) [a]	0.25	0.0036	0.00148	0.0247	117.8
	574 (1065) [b]	0.25	0.0039	0.00161	0.0258	123.0
	650 (1202) [a]	0.25	0.0039	0.0016	0.0258	139.8
	650 (1202) [b]	0.25	0.0040	0.00165	0.0261	141.4
Silicon carbide, CO_2 (density = 1.74 gm/cc)	574 (1065) [a]	0.25	0.0039	0.0017	0.027	128.5
	574 (1065) [b]	0.25	0.0039	0.0017	0.027	128.5
	650 (1202) [a]	0.25	0.0039	0.0017	0.027	146.0
	650 (1202) [b]	0.25	0.0042	0.0018	0.028	152.0

[a] with test casting 8 cm diameter and 16 cm long.
[b] with test casting 6.5 cm diameter and 13 cm long.

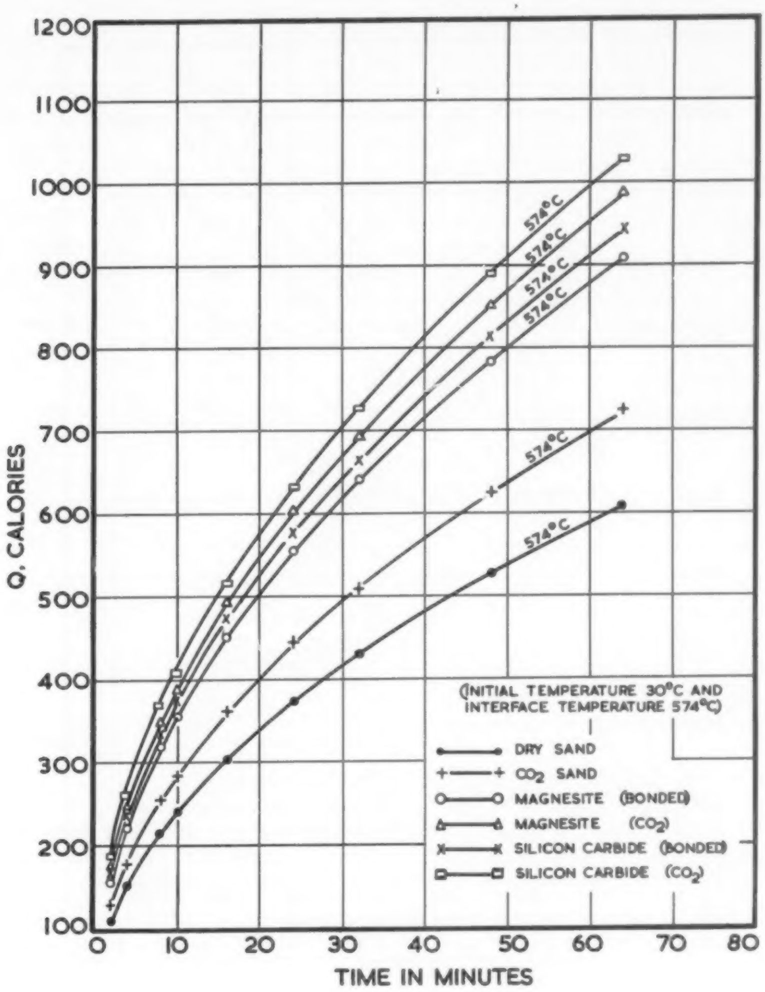


Fig. 4 — Total heat extracted by various mold materials at an interface temperature of 574 C (1065 F).

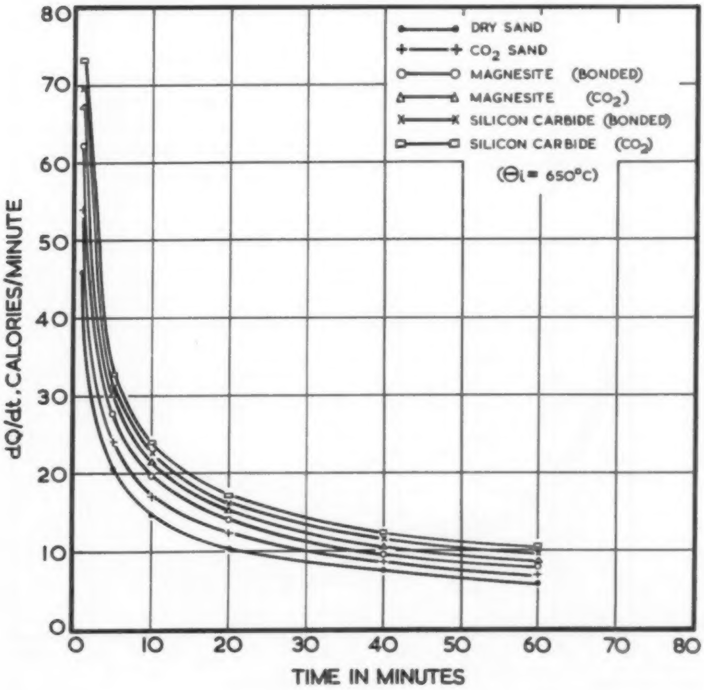


Fig. 5 — Rate of heat extraction from mold surface at an interface temperature of 574 C (1065 F).

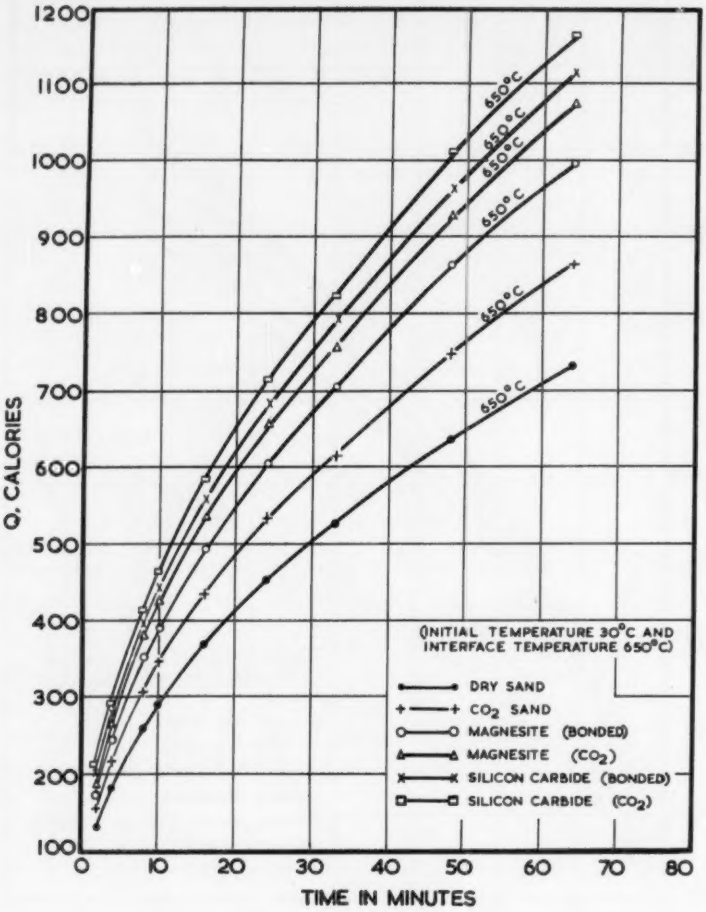


Fig. 6 — Total heat extracted by various mold materials at an interface temperature of 650 C (1202 F).

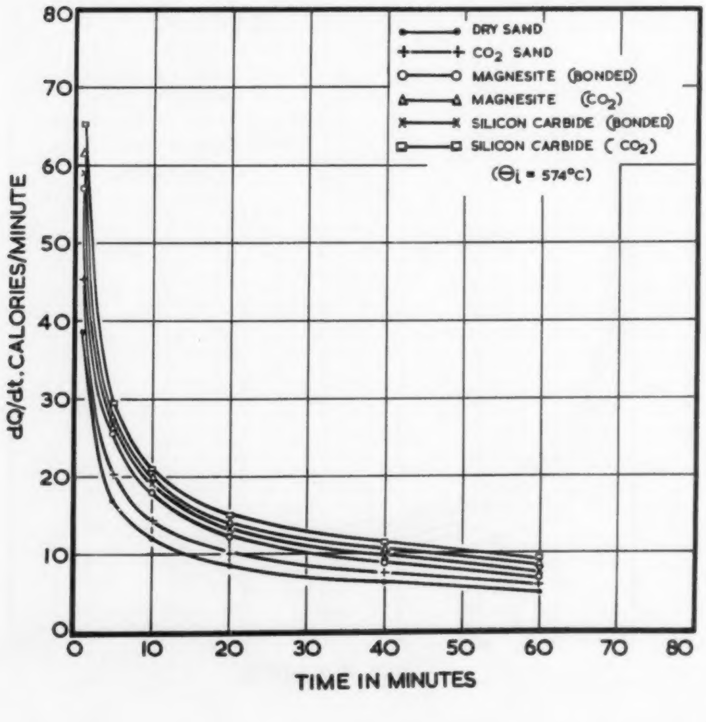


Fig. 7 — Rate of heat extraction from mold surface at an interface temperature of 650 C (1202 F).

molds is quite appreciable compared to sand molds. At an interface temperature of 574 C (1065 F), the total heat extracted and the rate of heat extraction per cm^2 of mold surface is more for magnesite (CO_2) and less for silicon carbide (bonded), Figs. 4 and 5.

Theoretical Solidification Time

From the thermal properties of nonmetallic mold materials listed in Table 2, and the data available in literature on the thermal characteristics of pure aluminum and aluminum-12 per cent silicon alloy unmodified, the theoretical solidification time (t_s)[14] of test castings were determined using the equation

$$t_s = \frac{R^2}{\left[\frac{\sigma b_2 v}{2 \rho_L \bar{q}_L} + \sqrt{\frac{v}{\rho_L \bar{q}_L}\left(\frac{\sigma^2 b_2^2 v}{4 \rho_L \bar{q}_L} + \frac{k_2}{c_1 c_2}\right)}\right]^2} \qquad (5)$$

where

$\sigma = 1.13.$
$v = \theta_i - \theta_o.$
$\bar{q}_L = L_L + C_L(\theta_L - \theta_s).$
ρ_L = density of molten metal or alloy.
θ_L = pouring temperature of metal or alloy.
θ_s = solidification temperature.
L_L = latent heat of fusion.
b_2 = heat diffusivity of mold material.
k_2 = thermal conductivity of mold material.
$c_1 = 2$ and $c_2 = 2$ for a cylinder.
R = volume/surface area ratio.

The solidification times calculated from equation (5) for the test castings of aluminum and aluminum-12 per cent silicon (unmodified) cast in various types of molds and the experimental solidification times were then plotted against the inverse of the square of the mold constant, i.e., $1/\xi^2$ Figs. 8 and 9. It can be seen from these figures that the solidification times of test castings is inversely proportional to the square of mold constant. This relationship found to hold good even on varying the size of the test casting.

Ruddle and Mincher's[8] experiments also reveal that the solidification time of test castings of pure copper and Aluminum-30 per cent copper alloy is inversely proportional to the square of the mold constant, Fig. 10.

However according to Figs. 8 and 9, it appears that the difference in experimental and calculated solidification times of Al-12 per cent silicon alloy (unmodified) test castings is more and is less in the case of pure aluminum. This variation may be attributed to the mode of solidification of pure metals and eutectics.

CONCLUSIONS

1. The thermal properties of new molding materials can be determined with ease by the unsteady state method involving melting and casting.
2. In general heat diffusivity values of mold materials bonded by CO_2 process will be higher compared to bentonite bonded.
3. Among the nonmetallic mold materials investigated silicon carbide (CO_2) has maximum heat diffusivity and synthetic sand the minimum.
4. Solidification times calculated from the thermal

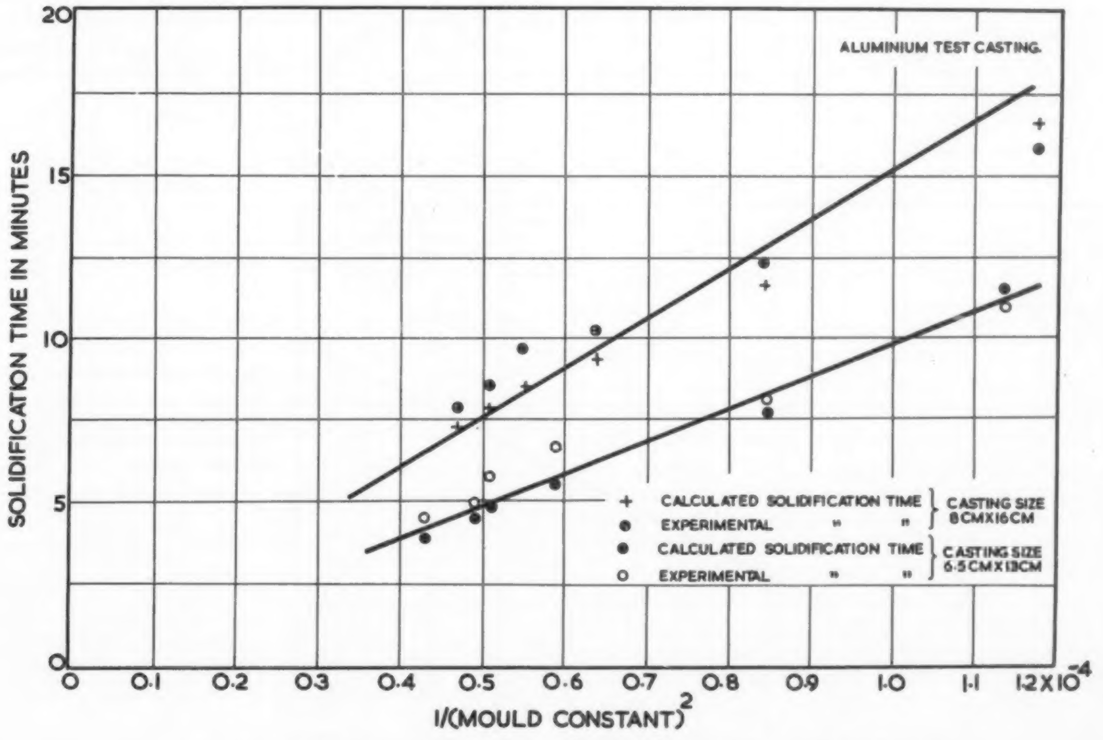


Fig. 8 — Solidification time vs. $\left(\frac{1}{\text{mold constant}}\right)^2$ for aluminum test casting.

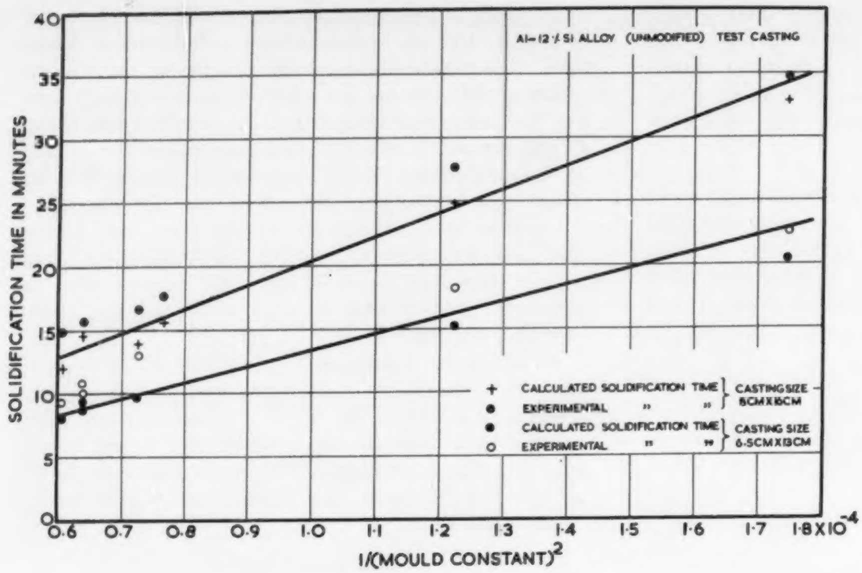


Fig. 9 — Solidification time vs. $\left(\frac{1}{\text{mold constant}}\right)^2$ for aluminum — 12 per cent silicon alloy.

properties of mold materials evaluated by the unsteady state method compare favorably with those of experimentally determined values.

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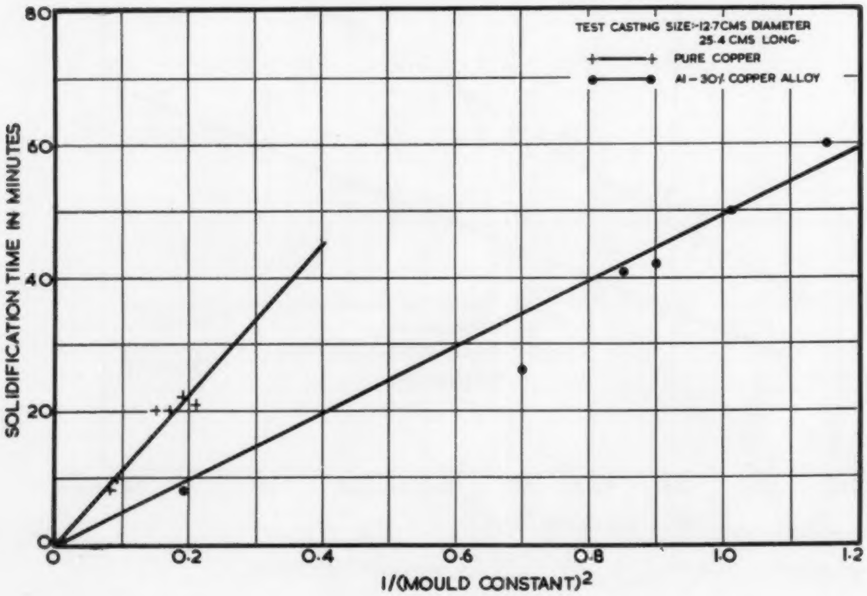

Fig. 10 — Solidification time vs. $\left(\frac{1}{\text{mold constant}}\right)^2$ for aluminum — 30 per cent copper and pure copper test castings.

FLUIDITY OF ALUMINUM ALLOYS

An experimental and quantitative evaluation

by M. C. Flemings, E. Niiyama and H. F. Taylor

ABSTRACT

Fluidity tests were conducted on aluminum-4.5 per cent copper alloy to determine the effects of small additions of a third element on fluidity. Elements studied included titanium, iron, manganese, cobalt, chromium, beryllium, silicon, magnesium, calcium and copper. Results observed were interpreted on the basis of the effects of the elements on (a) liquidus temperature, (b) solidification range and (c) nature of the primary crystals formed.

An equation was developed, based on heat and fluid flow considerations and on solidification theory to express fluidity of an alloy in terms of metal and mold variables. The equation describes fluidity behavior of mushy freezing alloys such as aluminum-4.5 per cent copper, qualitatively and quantitatively.

INTRODUCTION

In July 1957, a research program was initiated at Massachusetts Institute of Technology by the U.S. Army Ordnance Department through Pitman-Dunn Laboratory, Frankford Arsenal, to obtain a basic understanding of the factors affecting fluidity in aluminum alloys and, if possible, to develop practical methods for increasing fluidity. During the first two years' research on this program, tests were developed and employed to isolate the important variables affecting fluidity, and theoretical and experimental analyses were used to relate metal fluidity to:

1) Solidification mechanism.
2) Surface tension and surface oxide films.
3) Superheat.
4) Other metal and mold variables.

In addition, completely practical methods were developed to increase fluidity of aluminum alloys (in production) by as much as a factor of three.[1-4]

A portion of the research conducted during the third year of this program is described herein. It is a continuation of the earlier work, and was directed at (1) a study of effects on fluidity of adding third elements to aluminum-4.5 per cent copper alloy, and (2) developing a quantitative analysis of factors affecting fluidity of aluminum alloys.

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ADDED ELEMENTS EFFECT ON FLUIDITY OF ALUMINUM-4.5 PER CENT COPPER ALLOY

Test Apparatus and Procedure

Fluidity tests were conducted in the vacuum fluidity tester (Fig. 1) in essentially similar fashion to that described earlier.[2] In each test, metal of known composition and temperature was drawn into the fluidity test channnel under predetermined pressures. The distance the metal flowed into the tube was taken as the measure of fluidity. In some cases, the stream of flowing metal was photographed with a movie camera to provide accurate determination of flow velocity and fluid life (time of flow).

Glass tubes (0.200 $\pm$ 0.006 in. diameter) were used for the test channel, except where otherwise noted. To facilitate immersion in the liquid bath, one end of the tube was bent with a radius of about 4 in., with the horizontal portion of the fluidity channel 2.75 $\pm$ 0.25 in. above the entrance of the tube. After bending, the tubes were annealed at 800-900 F for 2-3 hr, and cooled to room temperature in the furnace to prevent breakage by heat shock during the test. The inside of the glass tubes cleaned with glass cleaner, rinsed and then dried immediately before testing by passing dry nitrogen through them for at least 20 min.

In testing, the tubes were immersed in the metal bath to a depth of approximately 0.6-0.8 in., so the horizontal portion of the tube was approximately 2 in. above the melt. Fluidity was measured as the distance from the melt surface to the end of the fluidity casting. When a photographic record of flow was desired, a 16 mm camera (64 frames/sec) was used. An electric clock was used so time and flow distance were recorded on the film simultaneously.

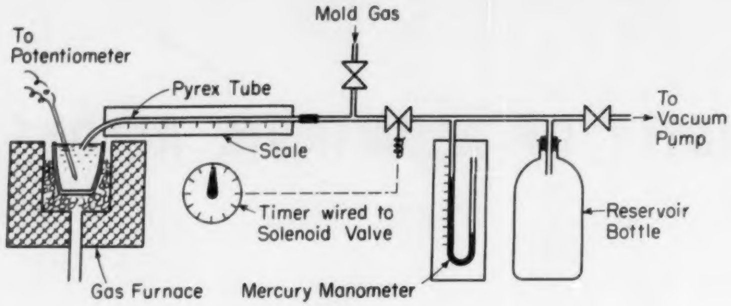

Fig. 1 — Vacuum fluidity test apparatus.

Melting was conducted in a clay-graphite crucible placed inside a gas-fired furnace. For some tests, a salt flux and/or nitrogen degassing was employed. However, small amounts of gas were found to have no significant effect on fluidity, and solidification and remelting (in the crucible) between runs kept the gas content adequately low. Melt temperature was measured using a chromel-alumel thermocouple with a protection tube of quartz or clay. The melt temperature at the instant of the test run was determined with an accuracy of $\pm$ 2 to $\pm$ 4 F.

Pressure was measured with a mercury manometer to within $\pm$ 1 mm Hg. This pressure was found to be unchanged when measured before and after testing. Pressures, in mm Hg, were converted to metal head (in. of aluminum) for subsequent calculations. Density of liquid 195 alloys (including the alloy with third additives) was taken as 2.42 grams/cc.

For tests in which a photographic record was taken, the procedure was—when the melt approached the testing temperature a fluidity tube was fixed in position for testing. The timer (Fig. 1) was started and the melt surface skimmed. At the precise melt temperature desired, the camera was started and the tube was dipped into the melt. At a predetermined time (0.3-0.7 sec), the vacuum was applied by opening a solenoid valve. After the test was complete, the timer and camera were stopped and the test tube removed.

Alloy Preparation

Metal for most of the tests reported was melted from pre-alloyed ingots made from a single master heat. This pre-alloyed ingot was prepared from electrode copper and high purity aluminum (99.99 per cent) to a composition of 4.30 per cent-balance aluminum, and for continuity is frequently referred to herein as aluminum-4.5 per cent copper alloy, or as 195 alloy. The difference in fluidity between actual analysis (4.3 per cent) and the nominal analysis for 195 alloy (4.5 per cent) is essentially negligible, estimated to be at about 2 per cent.

Third elements added included titanium, magnesium, silicon, iron, beryllium, manganese, cobalt, chromium, calcium and lead. To assure accurate and homogeneous additons of these elements, master alloys were first made from these metals and pure aluminum or aluminum-4.5 per cent copper alloy. The master alloys were then analyzed and added to the base alloys to obtain the desired compositions for testing. Except where otherwise noted, copper contents of the final alloys were adjusted to 4.3-4.5 per cent.

Precision of Tests

The precision of the vacuum fluidity test depends on the degree of control exercised over such factors as melt temperature, pressure head, tube diameter, radius of the bend in the tube, dip time, dip depth and cleanliness of the tube. Of these, tube cleanliness was found to have an unexpectedly large effect, apparently because thin films of impurities on the inside of the tubes affect heat transfer at the metal-glass interface. For most of the tests reported herein, the standard deviation of fluidity values was 3 per cent. In other words, 95 per cent of all the results fell in the range of $\pm$ 6 per cent of the average value, which was quite satisfactory for the present work.

Preliminary Tests

Before studying effects of alloy additions on fluidity, a series of standard tests were conducted with pure aluminum-4.5 per cent copper alloy. In these tests only temperature and pressure head were varied (Fig. 2). A linear relation between fluidity and melt temperature was obtained, as would be expected from previous researches[1-3, 6, 7] and from simple theory (outlined later).

Motion picture records were made of each of the standard tests to determine fluid life* accurately. Fluid life decreases with decreasing melt temperature and with increasing metal head (Fig. 3). This agrees with previous experimental findings.[2] Theoretical explanation for the foregoing has been given in general terms,[2, 7] and is presented quantitatively later. Briefly stated, the explanation is—in an alloy with a wide range of solidification (such as aluminum-4.5 per cent copper), fluidity is limited by choking of flow at the leading tip of the stream, due to accumulation of solid crystallites.

As pressure head is increased, flow velocity increases and the flow tip is exposed to more chilling by coming into contact with a greater area of the cold mold walls. The increased pressure head therefore results in increased rate of solidification at the flow tip, and hence decreased fluid life (increased super-heat increases fluid life because more heat must be withdrawn at the tip to effect sufficient solidification to stop flow).

*Fluid life is the length of time metal flows in the fluidity test channel before stopping.

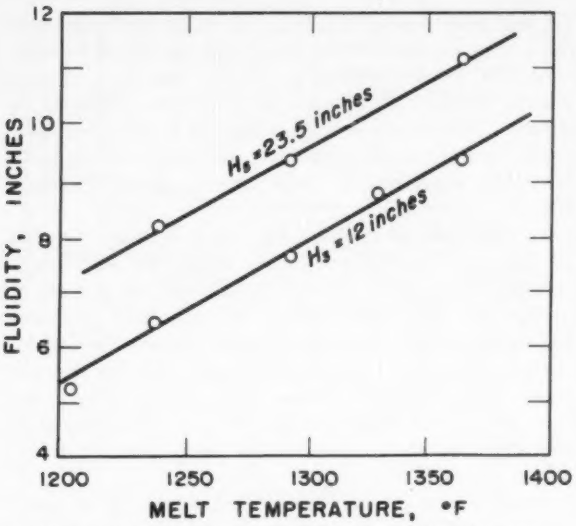

Fig. 2 — Melt temperature effect on fluidity for two different metal heads (tubes cleaned).

As additional evidence that choking occurs at the flow tip, it was observed several times in this research that when a tube was broken by the thermal stress at the instant of flow stoppage, almost all the metal in the tube flowed out, leaving only the extreme leading tip of the metal in the glass tube as a semi-solid. The length of this semi-solid part was sometimes less than ¼-in.

Grain Refinement Effect on Fluidity

In order to determine the effect of commercial grain refiners on the fluidity of 195 alloy, tests were made in which 0.17 per cent titanium was added to the aluminum-4.5 per cent copper alloy. Results of these tests (Fig. 4) show that titanium reduces fluidity approximately 13 per cent at the lower pouring temperature and 10 per cent at the higher temperatures.

The reason why titanium reduces fluidity is not clear. It may well be due to the results of the grain refinement process, since fine particles have been shown to be much more effective in stopping a flowing stream than an equivalent percentage by weight of coarse particles.[8] However, titanium also has a slight effect on the solidification behavior of aluminum alloys in addition to its grain refining action. This may also affect fluidity. The ways in which various alloys affect fluidity are discussed in detail in the following section.

Alloying Agents Effects

Data from many workers are in general agreement that alloying additions to pure metals nearly always result in reduced fluidity. However, the situation is quite different for alloys. For example, eutectic compositions in binary and ternary systems usually possess better fluidity than compositions which are richer or poorer in solute.[9-10] Also, various researches have shown that relatively small amounts of elements added to foundry alloys can bring about significant improvements in fluidity.[11-12]

Ways by which alloying elements can have beneficial effects on fluidity include (1) increase in superheat due to lowering of liquidus temperature, (2) change in temperature range over which solidification occurs, (3) change in the nature of primary crystals which form and (4) changes in the nature of surface films or oxides.

Items (1), (2) and (3) all suggest that alloys might increase fluidity of aluminum-4.5 per cent copper alloy if they form a "liquidus valley" in the ternary phase diagram composed of the alloy, aluminum and copper (if this valley is near the composition of aluminum-4.5 per cent copper). An example of what is meant by a liquidus valley is shown in Fig. 5, a portion of the pseudo-binary diagram for aluminum-5 per cent copper with iron added up to 3.0 per cent. At approximately 1.5 per cent iron a peritectic exists, and in this region some fluidity increase might be expected for one or more of these reasons:

1) The liquidus temperature is a minimum at 1.5 per cent iron. At this temperature it is 1188 F (642 C), compared with 1197 F (647 C) at 0 per cent iron and 1340 F (727 C) at 3.0 per cent iron. Hence, if fluidity is measured at constant pouring temperature, alloys of about 1.5 per cent iron will possess somewhat greater superheat due to depression of the liquidus.
2) The equilibrium temperature range of solidification is a minimum in the neighborhood of the peritectic. It is 140 F (60 C) at 0 per cent iron,

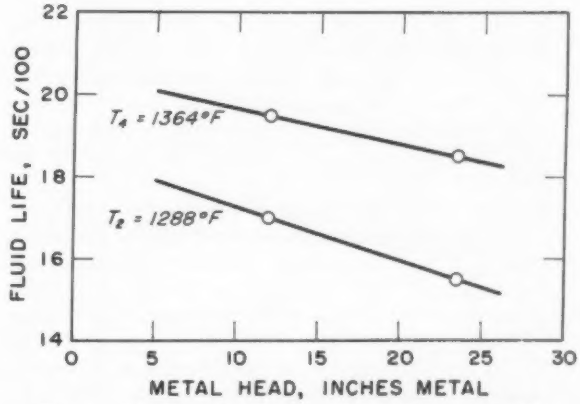

Fig. 3 — Metal head effect on fluid life for two different melt temperatures (tubes cleaned).

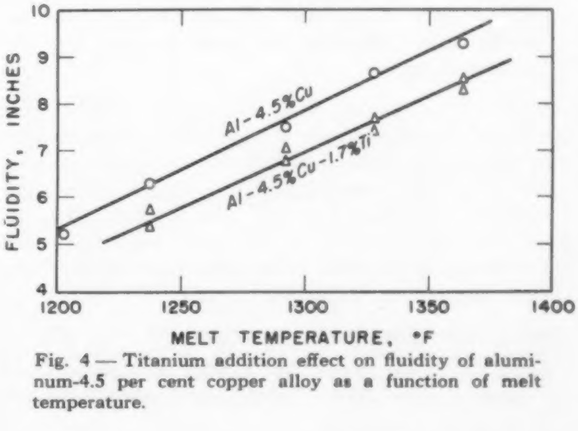

Fig. 4 — Titanium addition effect on fluidity of aluminum-4.5 per cent copper alloy as a function of melt temperature.

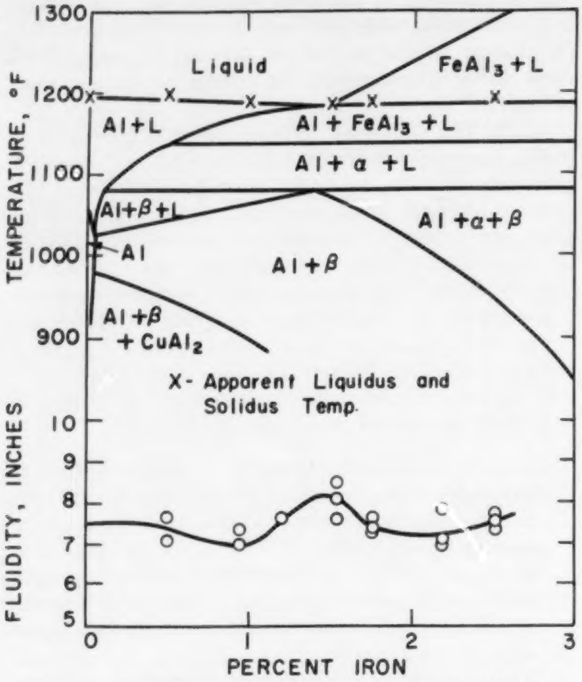

Fig. 5 — Iron effect on liquidus temperature (top) and fluidity (bottom) of aluminum-4.5 per cent copper alloy. Fluidity tests at 1288 F, 12 in. metal head. Phase diagram from references.[20,21]

110 F (49 C) at the peritectic and 260 F (127 C) at 3 per cent iron. While this is not always a guarantee of good fluidity, nonetheless, it has been observed in both binary and ternary systems that when the equilibrium temperature range of solidification is small, fluidity is likely to be high.[6, 9, 13, 14]

3) As the peritectic point is approached with increasing iron content, gradual changes in the mechanism of solidification (and hence fluidity) may be expected from the gradual changes in phase diagram relationships (such as temperature range of solidification, item 2). Above the peritectic point a major change in the mechanism of solidification occurs. The primary crystals that form are no longer a solid solution of aluminum and copper but are now the intermetallic compound $FeAl_3$. The heat of fusion of $FeAl_3$ is considerably higher than that of aluminum,[3] and so might affect fluidity by slowing the rate of solidification.

In this investigation, iron, manganese, cobalt, chromium and beryllium were selected for testing because they possess (or were expected to possess) a liquidus valley near aluminum-4.5 per cent copper. They were added to aluminum-4.5 per cent copper alloy in quantities up to about 3 per cent. Adjustments in composition of the base alloy were made to hold the copper constant at 4.3 to 4.5 per cent.

Iron, Cobalt, Chromium, Beryllium

Iron was found to decrease fluidity of aluminum-4.5 per cent copper alloy slightly until approximately 1.0 per cent was added (Fig. 5). Iron additions near the peritectic resulted in somewhat increased fluidity, probably for one or more of the reasons discussed above. Above 1.6 per cent iron had no influence on fluidity. The effect of manganese on fluidity was generally similar to that of iron, as would be expected from the similarity of their ternary phase diagrams, Fig. 6.

In the case of cobalt (Fig. 7) a ternary diagram is not available, but judging from the aluminum-cobalt binary, a liquidus valley should be present at about one per cent cobalt. With cobalt additions higher than this, the primary phase should be Co_2Al_9 rather than pure aluminum. Figure 7 shows the substantial increase in fluidity obtained at about one per cent cobalt, undoubtedly due to the presence of the liquidus valley and to the high heat of fusion of Co_2Al_9.[3]

From binary phase diagram relationships, it would be expected that chromium would also result in a liquidus valley (at about 0.5 per cent chromium). However, chromium has only a slight effect on the fluidity of 195 alloy, Fig. 8. Beryllium, in quantities of one to 2 per cent significantly improves fluidity of 195 alloy (Fig. 9). It appears likely that this is due to the large decrease in liquidus temperature (30 F at 1.5 per cent Be), although beryllium may also exert other effects on the mechanism of solidification.

Silicon, Magnesium, Calcium

Elements other than those discussed above which were studied herein included silicon, magnesium and calcium. Silicon was added (Fig. 10) because it is generally thought to promote fluidity. However, in

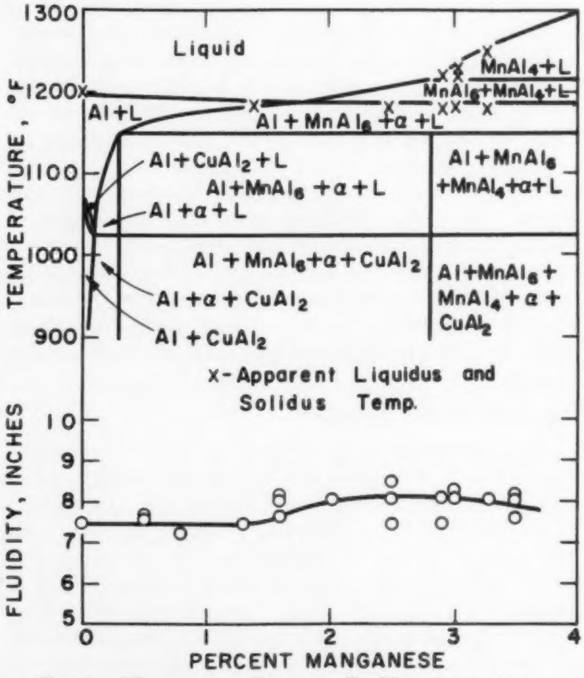

Fig. 6 — Manganese effect on liquidus temperature (top) and fluidity (bottom) of aluminum-4.5 per cent copper alloy. Fluidity tests at 1288 F, 12 in. metal head. Phase diagram from references.[20,23]

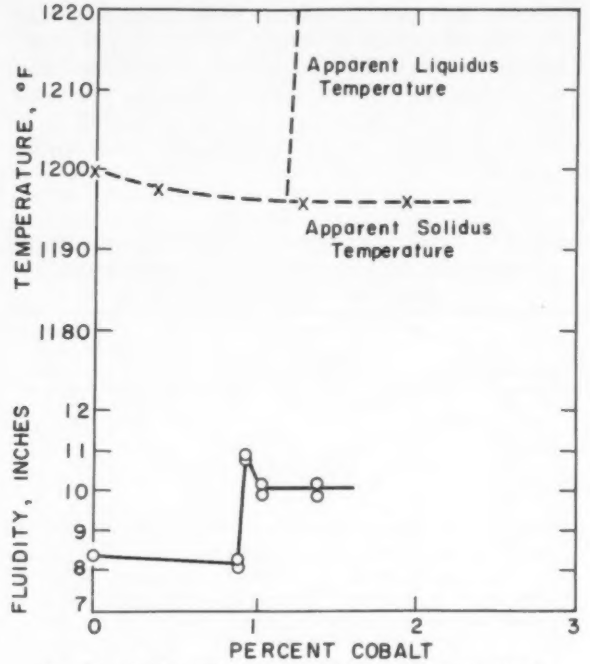

Fig. 7 — Cobalt effect on liquidus temperature (top) and fluidity (bottom) or aluminum-4.5 per cent copper alloy. Fluidity tests at 1328 F, 12 in. metal head.

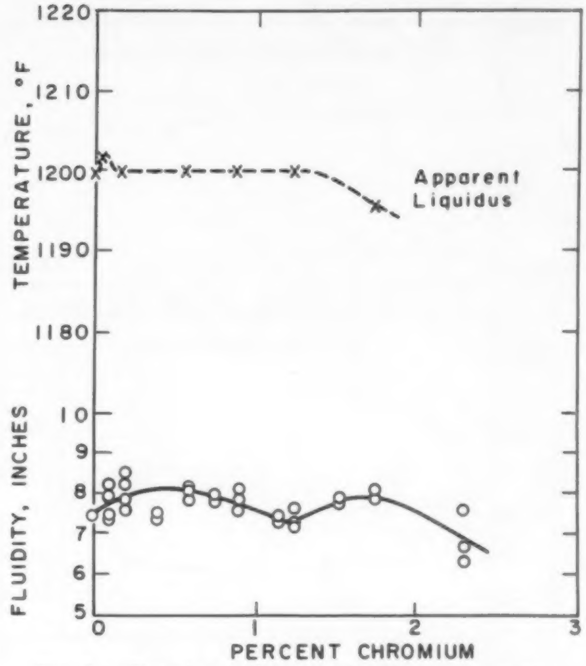

Fig. 8 — Chromium effect on liquidus temperature (top) and fluidity (bottom) of aluminum-4.5 per cent copper alloy. Fluidity tests at 1288 F, 12 in. metal head.

spite of the fact that silicon significantly lowers the liquidus temperature of aluminum-4.5 per cent copper alloy, no improvement in fluidity was found for amounts as high as 2 per cent.

Magnesium and calcium were selected for test because they are highly reactive and should affect fluidity of aluminum by changing the surface characteristics of the flowing stream. Beryllium, mentioned

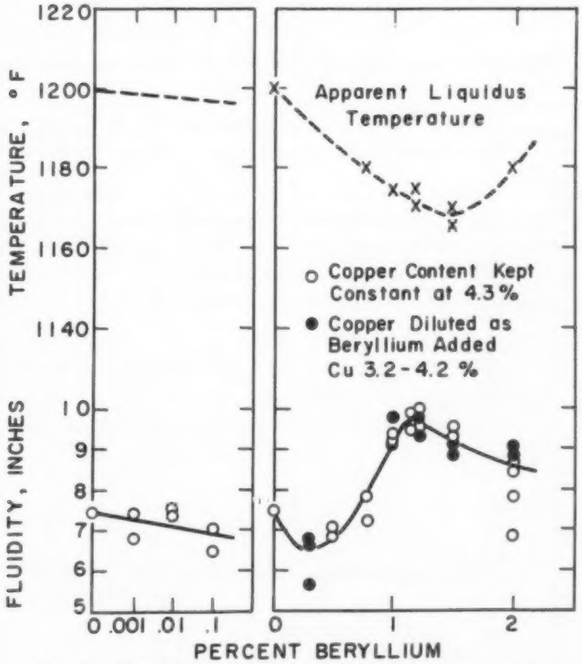

Fig. 9 — Beryllium effect on liquidus temperature (top) and fluidity (bottom) of aluminum-4.5 per cent copper alloy. Fluidity tests at 1288 F, 12 in. metal head. Magnesium was present as an impurity in amounts approximately equal to one-half the beryllium addition (Table 1).

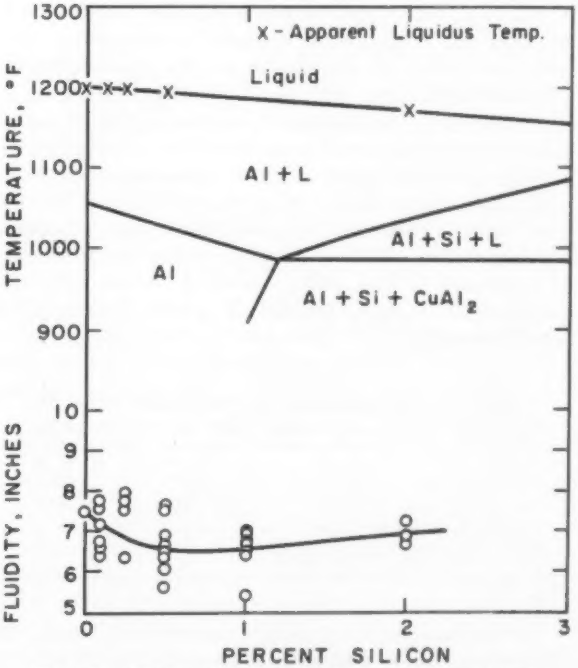

Fig. 10 — Silicon effect on liquidus temperature (top) and fluidity (bottom) of aluminum-4.5 per cent copper alloy. Fluidity tests at 1288 F, 12 in. metal head. Phase diagram from reference.[20]

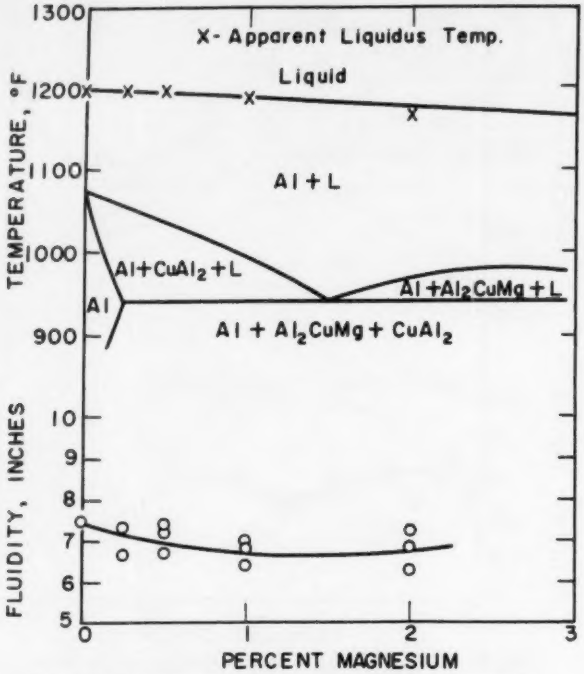

Fig. 11 — Magnesium effect on liquidus temperature (top) and fluidity (bottom) of aluminum-4.5 per cent copper alloy. Fluidity tests at 1288 F, 12 in. metal head. Phase diagram from references.[20,22]

earlier, was studied carefully in amounts up to 0.1 per cent, because it also was thought likely to affect the surface tension and/or surface film on flowing aluminum. Magnesium and calcium had little effect on fluidity of aluminum-4.5 per cent copper alloy (Figs. 11, 12), and beryllium had no greater effect than would be expected from phase diagram relationships; i.e., from the effect of beryllium on the mechanism of solidification.

To assure that changes in surface characteristics were not affecting fluidity in this system, motion picture records were made of the aluminum-copper alloy with and without beryllium addition, Table 1. Initial flow velocity was the same for both alloys studied, although fluid life and fluidity were quite different. If change in surface tension and/or surface films affected fluidity, some change in initial flow velocity would also be expected.[2]

TABLE 1 — ALUMINUM-4.5 PER CENT COPPER ALLOY WITH AND WITHOUT Be* ADDITION

Alloy, %	1.2 Be	0 Be
Fluidity, cm	24.5	19
Fluid life, sec	0.28	0.17
Initial flow velocity, cm/sec	160	160

*at 1288 F with 12 in. metal head

In the case of all alloying elements studied, except chromium, small additions decreased fluidity of 195 alloy. In most cases, alloys which decreased the liquidus temperature of 195 alloy most sharply also decreased fluidity most markedly (Table 2); larger additions increased fluidity. It is of interest to note that most alloys affected fluidity of 195 alloy in somewhat the same fashion as copper (Fig. 13). This is further indication that the various elements decreased fluidity by changing the mechanism of solidification, much as does increasing copper content in the binary system.[1,2]

TABLE 2 — SMALL AMOUNTS OF ADDED ELEMENTS EFFECTS ON FLUIDITY OF ALUMINUM-4.5 PER CENT COPPER ALLOY

Element added	Decrease in liquidus Temp., C/per cent*	Decrease in fluidity, cm/per cent
Be	13	12
Si	7	4
Mg	7	2.5
Fe	4	2
Cu	4	1.5
Ca	3	0
Co	2	0
Mn	2	0
Cr	0	−6

*As measured in this work; decrease is initial slope of measured apparent liquidus temperature, Figs. 5 - 13.

MATHEMATICAL ANALYSIS OF FLUIDITY OF ALLOYS

Equation and Qualitative Comparison with Experiment

Mathematical analyses of fluidity have been made for pure metals and for alloys such as steel, and are reported in the literature.[6,15,16] However, heretofore no satisfactory analysis has been developed for mushy freezing alloys such as aluminum-4.5 per cent copper

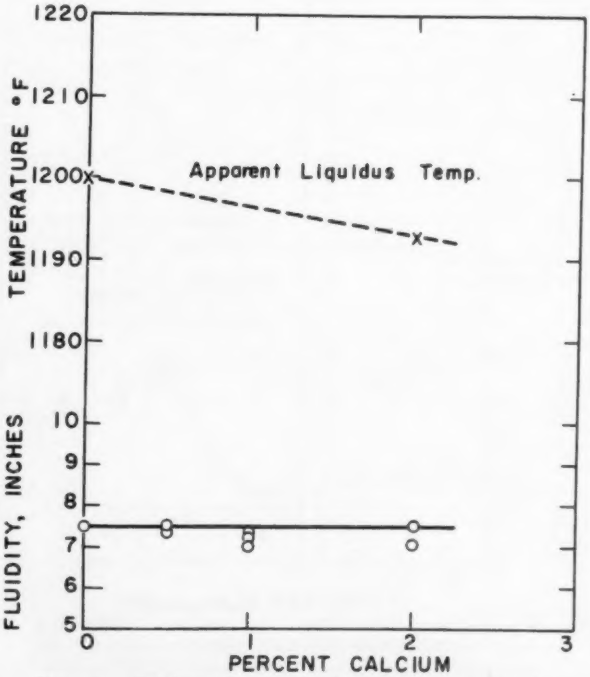

Fig. 12 — Calcium effect on liquidus temperature (top) and fluidity (bottom) of aluminum-4.5 per cent copper alloy. Fluidity tests at 1288 F, 12 in. metal head.

alloy. Such an analysis is presented in detail in the Appendix, and is based on a model for flow behavior of mushy alloys that assumes (1) solid particles form during flow in a fluidity channel and travel downstream with the liquid, (2) flow stops when the mean solid concentration near the flow tip reaches a certain value (critical solid concentration) and (3) flow velocity is constant until flow stops. These assumptions agree well with current understanding of the process of fluid[1,2] flow.

The basic equation derived in the Appendix expresses fluidity (L_f) in terms of metal and mold variables:*

$$L_f = \frac{A \rho V (k H_f + C \Delta T)}{Sh (T - Tr)} \left(1 + \frac{B}{2}\right) \qquad (1)$$

where:

$$B = \frac{h \sqrt{\Pi \alpha \Delta X}}{k' \sqrt{V}}$$

Examination of the individual terms shows that equation (1) predicts these effects in fluidity test results (in agreement with experimental results):

1) Fluidity increases linearly with the increase of superheat.
2) Fluidity is not zero at zero superheat.
3) Fluidity increases with increasing heat of fusion.
4) Fluidity increases with velocity of flow.

This (4) is generally proportional to the square root of pressure head ($V \alpha \sqrt{P}$). When B is small, fluidity also is proportional to the square root of pressure head ($L_f \alpha \sqrt{P}$), and when B is large fluidity is proportional to the fourth root ($L_f \alpha p^{1/4}$). In intermediate cases, the fluidity may be expressed approximately by $L_f \alpha p^n$ where n is between $\frac{1}{2}$ and $\frac{1}{4}$. For aluminum-tin alloys tested in the vacuum fluidity apparatus, n has been determined experimentally to be approximately 0.3.[1]

5) Fluidity is proportional to the ratio of the cross-sectional area to the circumference of the channel.

This (5) was also found to be true for fluidity tests made in glass tubes of various sizes. Equation (1) indicates that the fluid life increases with an increase in superheat but decreases with an increase in pressure head. This is also in agreement with experimental results.[1,2,7]

Numerical Comparison with Experimental Results

Equation (1) can be compared with experimental results in several ways. One is for the condition of fluidity at zero superheat:

$$L_{f(\Delta T = o)} = \frac{A \rho V k H_f}{Sh (T - Tr)} \left(1 + \frac{B}{2}\right) \qquad (2)$$

Another is by differentiating equation (1) with respect to superheat:

$$\frac{\delta L_f}{\delta \Delta T} = \frac{A \rho V C}{Sh (T - Tr)} \left(1 + \frac{B}{2}\right) \qquad (3)$$

and comparing the result with the slope of the curve of fluidity versus superheat.

*Definitions of symbols given in the Appendix.

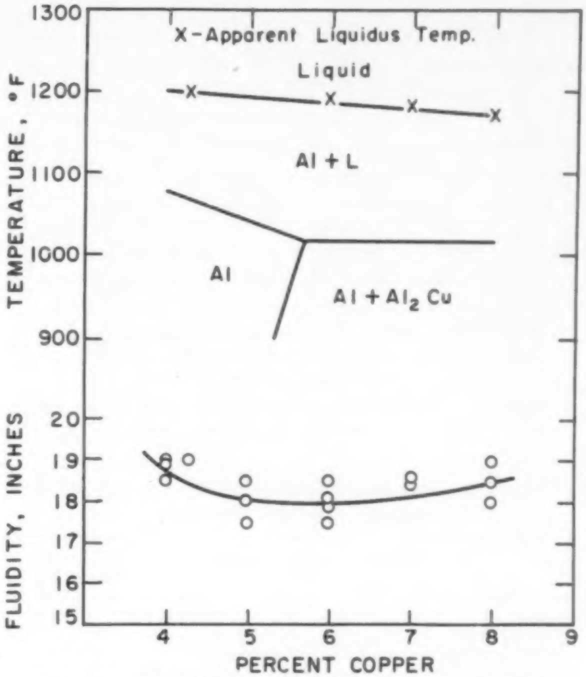

Fig. 13 — Increasing (and decreasing) copper content effect on liquidus temperature (top) and fluidity (bottom) of aluminum-4.5 per cent copper alloy. Fluidity tests at 1288 F, 12 in. metal head.

In solving the above equations, all terms were known or measured except k, h and ΔX. However, combining Equations (2) and (3), k can be expressed in quite simple form

$$k = \frac{C}{H_f} \cdot \frac{L_{f(\Delta T = o)}}{\frac{\delta L_f}{\delta \Delta T}} \qquad (4)$$

where the specific heat C and the heat of fusion H_f of the metal are known, and the two other factors in the right hand side of the equation can be determined experimentally. In fact, Equation (4) is quite general. It can be shown that equation (4) can be derived from a general heat flow formula

$$q = S.f(\Theta) \qquad (5)$$

and Equations (17) and (24) can be derived without making assumptions concerning the mechanism of heat transfer. From these, the following can also be derived

$$L_f \alpha \frac{A}{S} \qquad (6)$$

$$\frac{\delta L_f}{\delta \Delta T} = \text{constant} \qquad (7)$$

Using Equation (4) and experimental data obtained in the course of the research program,[2,3] critical solid concentration k was computed for 195 alloy (for glass tubes and sand molds). Data are listed in Table 3 and plotted in Fig. 14.

It is of interest that the critical solid concentration increases with increasing metal head, but that a limit appears to be reached at about 35 per cent solid.

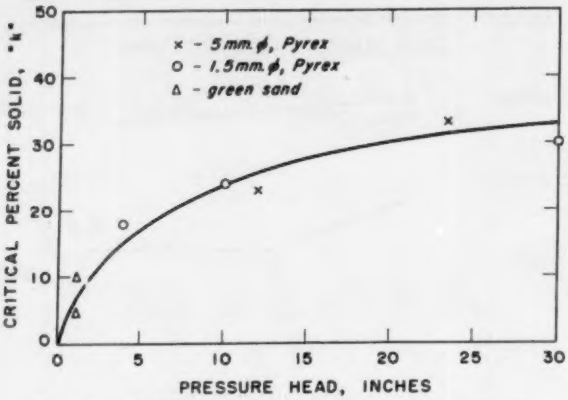

Fig. 14 — Calculated critical per cent solid at the tip of a fluidity test casting vs. pressure head.

TABLE 3 — METAL HEAD EFFECT ON CRITICAL SOLID CONCENTRATION

Mold	Metal Head, in. Al	Critical Solid Concentration, k, %
Glass (5 mm)	12	23
Glass (5 mm)	23.5	33
Glass (1.5)	4	18
Glass (1.5)	10	24
Glass (1.5)	30	30
Sand	(effective 2 in.)	5 (approx.)

TABLE 4 — VALUES OF TEST VARIABLES USED IN CALCULATING h COEFFICIENT IN FLUIDITY TESTS

Variable	Vacuum Test	Sand Mold Test	Units
A/S	0.125	0.127	cm
ρ	2.4	2.4	gms/cm^3
T	700	700	°C
Tr	20	20	°C
C	0.26	0.26	Cal/gm° C
H_f	94	94	Cal/gm° C
k′	2.7×10^{-3}	1×10^{-3}	Cal/sec cm° C
α	6×10^{-3}	2.5×10^{-3}	Cm^2/sec

TABLE 5 — VALUE OF HEAT TRANSFER COEFFICIENT EFFECT*

h, Cal/cm^{-2} sec°C	L_f, cm	$\delta L_f/\delta \Delta T$, cm/°C
0.020	58.1	0.555
0.040	32.2	0.302
0.060	23.2	0.218
0.080	18.8	0.176
0.100	16.1	0.151

*Effect on fluidity at 1350 F (732 C) and on slope of fluidity vs. temperature curve for aluminum-4.5% copper alloy in silica sand molds.

TABLE 6 — HEAT TRANSFER COEFFICIENT h EFFECT ON FLUIDITY

cal/cm^{2h} sec°C	L_f (T = 1350 F), cm	Change,* %
0.015	76.5	+200
0.053	25.5	Standard
0.071	20.4	−20
0.110	15.3	−40

*Value for standard green sand, uncoated mold taken as standard.

Further increases in pressure do not increase the amount of solid that can be moved. This is understandable in view of data cited earlier on various types of slurries which show the viscosity of these slurries increases very rapidly at a given consistency (usually in the range of 20 to 40 per cent solid).

Another factor which may affect k is solid particle size. With a constant pressure head, any change in k will change L_f (equation 2) but not $\delta L_f/\delta \Delta T$ (equation 3). Therefore the straight line of fluidity versus temperature will be shifted when k is changed. This kind of shift was observed when titanium was added to the 195 alloy. k for the alloy with titanium was found to be 19 per cent, while that for the 195 alloy was 23 per cent.

Subsequent calculations comparing theory and experiment were made using the values for k predicted by Fig. 14, and assuming ΔX to be one cm. Values of other test variables are given in Table 4. One calculation was to determine the heat transfer coefficient h at the mold-metal interface, for fluidity tests in glass tubes, using equations (2) and (3) independently. This was done for experiments at several different pressures, or metal heads (experimental data shown in Figs. 2 and 3). Values of h obtained fell between 0.15 and 0.30 cal/cm^2 sec°C, which is the general range to be expected.[7]

In the case of the spiral fluidity test in green sand mold used in other parts of this research, calculations of h were made from experimental observations of fluidity at 1350 F (732 C) using equation (2), and from experimental observation of the slope of the fluidity curve versus temperature using equation (3). Analysis was not made using data at zero superheat, because any temperature losses in the runner system would then have too great effect on calculated heat transfer coefficients.

In the case of spirals poured in uncoated green sand molds, the observed value for fluidity at 1350 F (732 C) is 25.5 cm, and the slope of the curve of fluidity versus temperature is 0.224 cm/°C. These observations indicate the h coefficients to be approximately 0.05 cal/sec °C (Table 5).

As reported earlier, certain mold coatings such as hexachloroethane and carbon black increase fluidity in green sand molds by as much as a factor of three.[2,4] On the other hand, the use of certain core sands instead of green sand results in decreases of fluidity from 20 to 40 per cent.[3] Changes in the heat transfer coefficient h that would account for such changes in fluidity were calculated, and are shown in Table 6. k was assumed to be 5 per cent and $\alpha C = 2.5 \cdot 10^{-3}$ cm^2/sec°C.

The heat transfer coefficient need be reduced by less than a factor of 4 to result in a 200 per cent increase in fluidity (triple fluidity). Doubling h results in as much as 40 per cent decrease in fluidity. It is of interest that the heat transfer coefficient need be affected only for an extremely short time to influence fluidity. For example, in a typical test in a fluidity spiral, metal velocity V is 80 cm/sec, and the choking zone (ΔX) is one cm. The average time the tip of the metal is in contact with any single portion of the mold is $1/80 = 0.013$ sec.

CONCLUSIONS

1. Grain refinement by addition of 0.17 per cent titanium decreases fluidity slightly (10 to 13 per cent).
2. Elements added to aluminum-4.5 per cent copper alloy (or present as impurities) in amounts up to about 3 per cent have a relatively small effect on fluidity. Elements tested to reach this conclusion were iron, manganese, cobalt, chromium, beryllium, silicon, magnesium, calcium and copper. Maximum improvements in fluidity observed were 25 per cent at one per cent beryllium, and 28 per cent at one per cent cobalt.
3. Small amounts of solute elements added to aluminum-4.5 per cent copper alloy generally decrease fluidity slightly. Elements which cause the largest decrease in fluidity are those that decrease the liquidus temperature most markedly. Effects of small amounts of alloying elements on fluidity are quite small, and it therefore appears likely that the impurities normally present in 195 alloy (high purity or commercial purity) do not affect fluidity of the alloy significantly.
4. Increased amounts of alloying elements tend to increase fluidity. In particular, fluidity was found to increase at the composition of liquidus valleys (at or near ternary compositions where the liquidus temperature was a minimum). These increases in fluidity are attributed to (a) increased superheat resulting from the lower liquidus temperature, (b) narrower temperature range of solidification and/or (c) change in the nature of primary crystals which formed.
5. In all probability, certain of the elements added (notably magnesium, calcium, beryllium), affected surface tension and/or surface films. However, any such changes did not affect fluidity significantly.
6. Experimental results confirm the theory that solidification of mushy alloys such as aluminum-4.5 per cent copper alloy, and hence cessation of flow in fluidity tests, occurs primarily by precipitation of fine grains near the leading tip of the flowing stream.
7. On the basis of certain simplifying assumptions, including that of mushy solidification, an equation was derived to express the fluidity of an alloy in terms of metal and mold variables.
8. The features of fluidity of alloys are accounted for qualitatively by the equation:
   (a) Linearity between fluidity and superheat.
   (b) Finite fluidity at zero superheat.
   (c) Effect of heat of fusion on fluidity.
   (d) Effect of metal head on fluidity ($L_f \alpha p^n$).
   (e) Proportional dependence of fluidity on the ratio of cross-sectional area to circumference.
   (f) Decrease in fluid life with increase in pressure head.
9. The equation is in reasonable agreement quantitatively with fluidity data obtained experimentally with the vacuum fluidity tester and in the sand mold fluidity spiral, assuming heat transfer coefficients to be 0.30 cal/cm^2 sec° C, and 0.05 cal/cm^2 sec° C in the glass and sand mold, respectively, and assuming solidification occurs primarily in a narrow zone at the tip of the flowing stream.
10. Comparison of theory with experiment shows improvements in fluidity obtained by use of mold coatings can be explained by reduction of the heat transfer coefficient h at the mold-metal interface. A probable reason why fluidity is lower in core sand than green sand is that h may be higher in core sand molds.
11. A simple formula was derived to determine the value of critical solid concentration k from experimental data (critical solid concentration is per cent solid near the tip of the fluidity spiral at the instant flow ceases). k was found to depend on metal head, but was independent of the size of the test channel. The maximum value observed was about 35 per cent.
12. The effect of titanium in decreasing fluidity of 195 alloy can be explained by its grain refining effect.

ACKNOWLEDGMENT

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APPENDIX

MATHEMATICAL ANALYSIS OF FLUIDITY OF ALLOYS

Assumptions

1) All the solid particles formed in the fluidity channel flow downstream with liquid.
2) Flow stops when the mean solid concentration in a zone near the flow tip reaches a certain value (critical solid concentration).
3) Velocity of flow is constant until the flow stops.
4) In considering heat flow, the mold wall is regarded as flat and infinitely thick. Heat resistance at the metal-mold boundary and heat flow in the mold are considered. The correctness of these assumptions are examined below.

Consider liquid metal with some superheat entering a fluidity channel. After the metal reaches the liquidus temperature, solidification takes place along the channel. Since the alloy solidifies over a wide range of temperature, it may be assumed that all the solid is floating as particles in the liquid instead of clinging to the mold wall. These particles will flow downstream together with the liquid. At the tip of flow will be found the highest concentration of particles, since solidification rate is highest at this point because of the freshness of the mold wall.

It has been established experimentally that flow of an alloy with a wide range of solidification temperature in a fluidity channel stops when it is choked with accumulated solid particles at or near the tip.[1,2,4] This happens when the solid concentration is much less than 100 per cent. From studies on quartz and graphite particles in an organic liquid,[11] clays[17] and pulp,[18] two general conclusions can be drawn concerning the flow behavior of a mixture of liquid and solid particles:

1) There is a certain critical concentration of solid particles at which viscosity of the mixture and hence resistance to flow increases rapidly to a high value.
2) The finer the particles, the lower is the critical concentration. Probably the critical concentration also depends upon particle shape, flow velocity, channel size, etc.

In applying this concept of critical solid concentration to our fluidity problem, it is reasonable to consider the mean solid concentration in a certain finite zone near the tip, since mixing of solid and liquid takes place. For the present, this zone will be called the choking zone.

It should be possible to express the pressure drop in flow as a function of mean solid concentration at the tip and perform some integral calculations to get flow velocity as a function of time. Pressure, or head loss, due to wall friction along the channel, should be taken into consideration to account for changes of velocity with time. However, for the sake of simplicity it is assumed here that flow velocity is constant until the flow stops suddenly when the mean solid concentration in the choking zone reaches the critical value. This is, in fact, nearly what is observed experimentally.[2]

To examine the assumptions employed in heat flow calculation, the vacuum fluidity test in a glass tube is used as a model. First, the validity of the assumption of a semi-infinite mold is checked. Temperature distribution in a concave cylinder (radium *R*) heated from inside in a short time is expressed by[19]

$$\frac{T - Tr}{Tm - Tr} = \sqrt{\frac{R}{r}}\left(1 - \operatorname{erf}\frac{r - R}{2\sqrt{\alpha\Theta}}\right) \qquad (8)$$

To find the temperature rise on the outside surface of the tube immediately after completion of a test the following typical values might be substituted in equation (8)

$R = 0.25$ cm, $r = 0.35$ cm, $\alpha = 6 \times 10^{-3}$ cgs and $\Theta = 0.2$ sec.

Then

$$\frac{T - Tr}{Tm - Tr} = 0.04$$

Since the temperature rise on the outside surface is only 4 per cent, this tube can be assumed to be an infinitely thick pipe. In a sand mold, where the mold is much thicker, the validity of the assumption is apparent.

Next, the assumption of plane mold wall is checked. Disregarding the heat resistance at the boundary, heat absorption by a semi-infinite plane is[19]

$$\frac{Q}{A} = \frac{2\,k'\,(Tm - Tr)}{\sqrt{\Pi\,\alpha}}\sqrt{\Theta} \qquad (9)$$

while that by a semi-infinite concave cylinder is[19]

$$\frac{Q}{A} = \frac{2\,k'\,(Tm - Tr)}{\sqrt{\Pi\,\alpha}}\left(\sqrt{\Theta} + \frac{\sqrt{\Pi\,\alpha}}{4\,R}\Theta\right) \qquad (10)$$

The relative error due to use of equation (9) instead of the equation (10) is

$$\frac{\frac{\sqrt{\Pi\,\alpha}}{4\,R}\Theta}{\sqrt{\Theta}} = \frac{\sqrt{\Pi\,\alpha\,\Theta}}{4\,R} \qquad (11)$$

Substitution of numerical values for the variables gives the error to be 6 per cent, which is reasonably small. As noted in the test, the time interval that should be considered is much shorter than the overall test time taken for the above calculations ($\Theta = 0.2$ sec). As a result, errors due to both the above assumptions are even smaller than those calculated above.

Analysis

Considering the heat resistance at the mold-metal interface, the rate of heat transfer from metal to mold in a unit length of the channel is

$$q_1 = S\,h\,(T - Tsc) \qquad (12)$$

where the boundary temperature Tsc is unknown. On the other hand, the rate of heat flow in the mold is

$$q_2 = \frac{S\,k'\,(Tsc - Tr)}{\sqrt{\Pi\,\alpha}}\,\frac{1}{\sqrt{\Theta}} \qquad (13)$$

Since q_1 must be qual to q_2, Tsc can be eliminated by combining (12) and (13), and the heat flow rate is

$$q = \frac{S\,h\,(T - Tr)}{1 + \dfrac{h\sqrt{\Pi\,\alpha\,\Theta}}{k'}} \qquad (14)$$

It is seen that the type of heat flow is determined by the factor $h\sqrt{\Pi\,\alpha\,\Theta}/k'$. When $h\sqrt{\Pi\,\alpha\,\Theta}/k'$ is small (much less than one), equation (14) becomes

$$q = S\,h\,(T - Tr) \qquad (15)$$

Thus the heat flow rate is controlled by the boundary resistance and is constant all the time. On the other hand, when $h\sqrt{\Pi\,\alpha\,\Theta}/k'$ is large (greater than one), equation (14) becomes

$$q = \frac{S\,k'\,(T - Tr)}{\sqrt{\Pi\,\alpha}}\,\frac{1}{\sqrt{\Theta}} \qquad (16)$$

and the heat flow rate, controlled by the heat flow process in the mold, decreases with time. When $h\sqrt{\Pi\,\alpha\,\Theta}/k'$ has a value the order of one, then equation (14) must be used as such and the rate of heat flow is controlled both by the boundary and the mold.

Starting from the general equation (14), the heat flow rate at a point *x* cm away from the flow tip is considered. Assuming a constant flow velocity, the time elapsed since the first metal touched the point is

$$\Theta = \frac{x}{V} \qquad (17)$$

Therefore the heat flow rate is

$$q = \frac{S\,h\,(T - Tr)}{1 + \dfrac{h\sqrt{\Pi\,\alpha}}{k'}\sqrt{\dfrac{x}{V}}} \qquad (18)$$

Notice that *q* is a function of the position relative to the flow tip but is not a function of time. We are interested in the mean heat flow rate in the "choking zone" ΔX. That is

$$qm = \frac{1}{\Delta X}\int_o^{\Delta X} q\,dx$$

$$= \frac{1}{\Delta X}\int_o^{\Delta X} \frac{S\,h\,(T - Tr)}{1 + \dfrac{h\sqrt{\Pi\,\alpha}}{k'}\sqrt{\dfrac{x}{V}}}\,dx \qquad (19)$$

and

$$qm = S\,h\,(T - Tr)\,\frac{2}{B^2}\{B - \ln(1 + B)\} \qquad (20)$$

where

$$B = \frac{h\sqrt{\Pi\,\alpha\,\Delta X}}{k'\sqrt{V}} \qquad (21)$$

Equation (20) can be approximated with errors less than 10 per cent for any value of *B* by

$$qm = S\,h\,(T - Tr)\,\frac{1}{1 + \dfrac{B}{2}} \qquad (22)$$

The total heat flow in a unit length of the channel from time zero to Θ is simply:

$$Q = S\,h\,(T - Tr)\,\frac{1}{1 + \dfrac{B}{2}}\,\Theta \qquad (23)$$

The heat to be subtracted from the metal by the time the flow stops is a sum of the superheat plus a part of the heat of fusion

$$Q = A\,\rho\,(k\,H_f + C\,\Delta T) \qquad (24)$$

where k is the critical solid concentration (in per cent).

Fluid life is obtained by equating (23) and (24)

$$\Theta_f = \frac{A\,\rho\,(k\,H_f + C\,\Delta T)}{S\,h\,(T - Tr)}\left(1 + \frac{B}{2}\right) \qquad (25)$$

and the fluidity is

$$L_f = V\,\Theta_f$$

$$= \frac{A\,\rho\,V\,(k\,H_f + C\,\Delta T)}{S\,h\,(T - Tr)}\left(1 + \frac{B}{2}\right) \qquad (1)$$

This is the basic equation expressing the fluidity of an alloy in terms of metal and mold variables.

A = Mold surface area, cm².
$B = h\sqrt{\Pi\,\alpha\,\Delta X}\,/\,k'\sqrt{V}$
$\quad = L\sqrt{\Pi\,\Delta X}\,/\,\sqrt{C'\rho' k' V}$
C = Specific heat of metal, cal/gm °C.
C' = Specific heat of mold, cal/gm °C.
H_f = Heat of fusion of metal, cal/gm.
h = Heat transfer coefficient at metal-mold interface, cal/cm² sec. °C.
k = Critical solid concentration, dimensionless fraction (or per cent).
k' = Thermal conductivity of mold, cal/sec. cm. °C.
L_f = Fluidity, cm.
Q = Total heat entering mold per unit length, cal/cm.
q = Heat flow rate from metal to mold per unit length, cal/cm sec.
R = Radius of mold channel, cm.
r = Radius of concentric cylinders in mold, cm.
S = Circumference of mold channel, cm.
T = Temperature of liquid metal, C.
Tm = Melting temperature, C.
T_{sc} = Mold temperature at interface, C.
Tr = Room temperature, C.
V = Velocity of metal flow, cm/sec.
α = Thermal diffusivity of mold $= k'/C'\rho'$, cm²/sec.
ΔX = Choking range, cm.
ρ = Density of metal, gm/cm³.
ρ' = Density of mold material, gm/cm³.
Θ = Time, sec.
Θ_f = Fluid life, sec.

ENGINE CASTINGS DEVELOPMENT BY EXPERIMENTAL STRESS ANALYSIS

by L. A. Grotto

ABSTRACT

The development of the principle engine castings by experimental stress techniques are discussed. How data are obtained from experimental techniques, using stress coat and strain gages, is shown and correlated with material properties. The test work shows that it is important to design a casting to minimize the assembly stress, as well as the working stress. It also proved that it is not necessary to make a casting heavy to make it strong.

Physical testing showed that the strength of the casting could not be predicted from test bars. However, by making the foundryman a member of the team, and working closely with him, it was possible to develop the material so it would satisfy the requirements of easy machining and high strength.

Summarizing, the report covers the development of a casting design and its material with the cooperation of the man in the foundry.

INTRODUCTION

This discussion will be concerned with the development of castings that make up the crankcase assembly – namely, the crankcase, bearing caps and the cylinder liners.

The principal castings used in the manufacture of high output automotive type diesel engines must combine maximum strength and minimum weight in such a manner to provide acceptable life and reliability. This is quite an order to expect from a structural assembly as indeterminate as that making up the crankcase assembly. Therefore, the design and development of such a casting requires the use of all the experience, knowledge and specialized tools and techniques the designer can muster. Furthermore, an unusual amount of teamwork between the designer and the foundryman is necessary to obtain the required casting for the final successful product.

This assembly is a challenge to the designer. It is difficult, if not impossible to predict structural adequacy from calculations. Furthermore, the material properties are not homogeneous, and the strength depends on such things as mass and cooling rate, as well as composition and hardness. In use, this assembly is subject to high force from assembly, combustion and inertia. These forces, of course, can combine and produce stresses which will cause fatigue in the structure.

This assembly is also a challenge to the foundryman. The crankcase is a difficult casting to produce because thin walls and heavy bosses are combined in a large mass. Furthermore, it must have high strength in the main bearing area, an area of relative slow cooling, and it must be easy to machine, even in areas where the cooling rate is fast, such as the pan rail and the top deck. The bearing caps on the other hand are small, massive castings requiring consistently high strength. The cylinder liners present special problems because the material here must not only have high strength, but also good wear and skuff resistance properties.

PREVIOUS TESTING METHOD

In the past, the design of this assembly drew heavily on the experience of the designer with prior designs operating under similar loads. Furthermore, tests under full load operation were run for thousands of hours to prove the structural integrity of the assembly. It is obvious that such a method is time consuming if the background of experience is not applicable to new design. Furthermore, the results of such tests are of the "Go or No-Go" variety, and development with this method will probably be "Add To" and "Beef It Up," resulting in unnecessary and excessive weight.

The experimental stress analysis techniques make it possible to determine if a structure is adequate, without operating the assembly for a long period of time. Quantitative values are obtained so that it is possible to know if the assembly is conservative or borderline. Areas of high stress are pinpointed as well as areas of low stress, and a concise knowledge of

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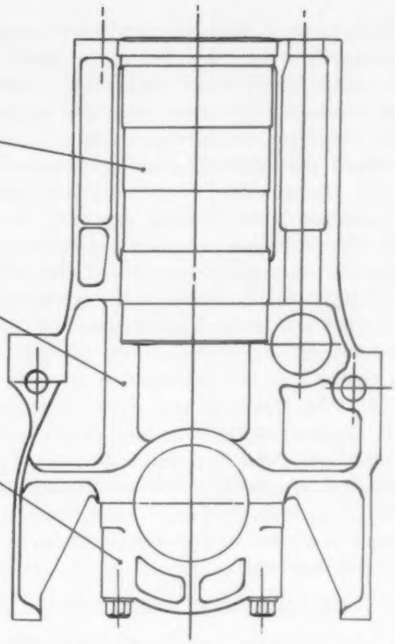


Fig. 1 — Castings used in diesel engine crankcase assembly.

how the loads are carried through the structures is obtained. The effect of changes can also be evaluated with concise numbers. This makes it possible to develop a satisfactory structure in less time, without extensive, specific experience.

Figure 1 is a cross-section of the assembly to be discussed, so that the relative location of the parts are apparent. This assembly makes up a large, automotive type high speed diesel engine, which has a displacement of 817 cu in., and develops 375 hp at 2100 rpm. This engine was a radical departure from engines that were previously manufactured by the author's company.

Previous engines were large, heavy, low speed engines of the precup design, which had relatively low firing pressures, while this engine is a light, high speed, high output, turbo-charged, direct injection engine with high firing pressures. This is also the first engine built in the author's company's construction equipment division in which experimental stress analysis techniques were used extensively.

GRAY IRON STRESS ANALYSIS

Preliminary studies were carried out on gray iron which gave many interesting and surprising results. The first was that test bars and other test specimen cast with the castings had little in common with the casting, even though they were made from the same material at the same time. In general, it was found that the properties of test specimen taken from critical areas of the castings were much lower than the properties determined from a test specimen cast at the same time.

It was not uncommon to find that the test specimen had properties 50 per cent higher in tensile strength, and 100 per cent higher in bending fatigue strength than a specimen taken directly from the casting. Even the microstructures were found to be different, Fig. 2.

The effect of repeated loading on gray iron was also interesting. The first loading produced the typi-

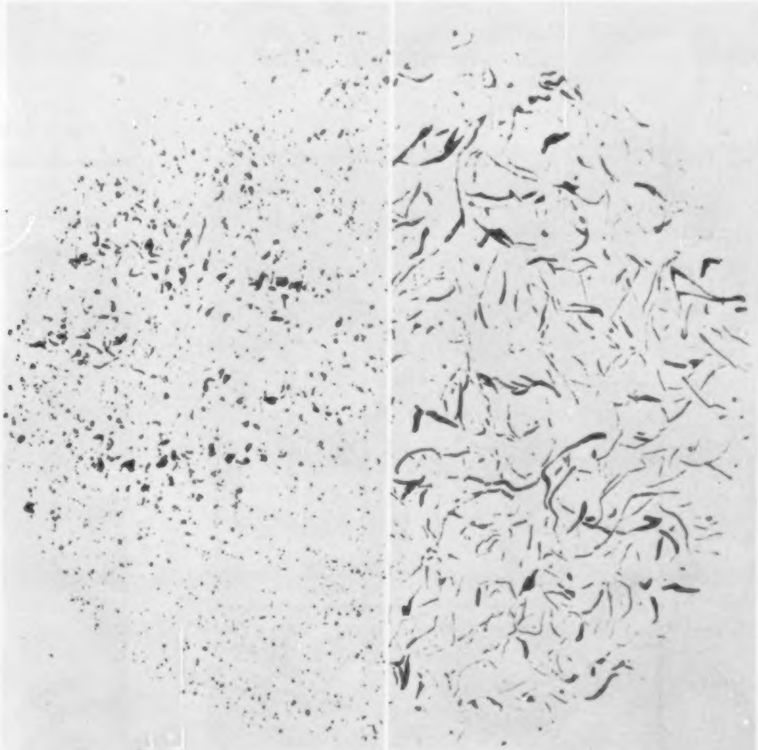


Fig. 2 — Microstructural difference between test bar and casting. *Left* — Material cast in test bar. *Right* — material in crankcase.

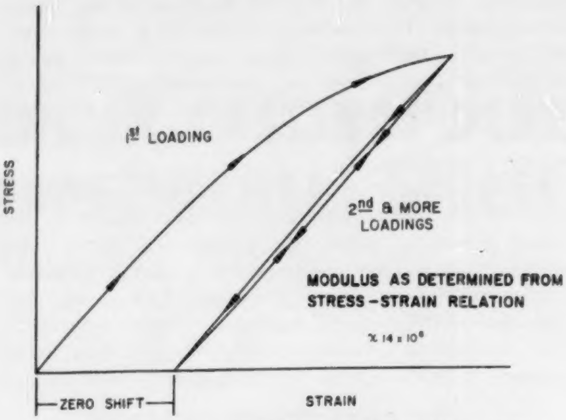


Fig. 3 — Gray iron stress-strain characteristics under repeated fluctuating load.

cal stress-strain curve for gray iron in which the modulus is not a constant. This had been observed many times during loading of a tensile specimen to the ultimate. However, when the load on the specimen was stopped short of the ultimate, released and re-applied, it was found that:

1 During the first loading, the typical gray iron stress-strain curve was observed.
2. As the load was released, the stress-strain path of unloading differed from the stress-strain path of loading, and an apparent zero shift was observed on the strain coordinate.
3. After the first loading, the material appeared to have a constant modulus of elasticity, providing the loading did not cross the zero line. This phenomena is illustrated in Fig. 3.

Based on a limited number of tests the decision was made to use 14×10^6 as the modulus of elasticity for gray iron when evaluating strength, although variations in modulus were observed ranging from 11.5×10^6 to 16×10^6.

Based on literature studies, the decision was made to use the modified Goodman diagram as a means of determining the fatigue strength of the structure. The envelope was constructed by taking the reversed bending strength as one-third the ultimate strength and having the lines of the envelope meet at the ultimate strength. The fatigue strength with a compressive mean stress is taken to have the same range as that where the mean stress is zero.

For the types of gray iron used in this assembly, the fatigue strength at zero mean load was taken at 10,000 psi, and the envelope joined at 30,000 psi, which was considered the ultimate of the material. This is shown on Fig. 4. This analysis has been successful in gray iron castings of this type and is being used extensively.

CRANKCASE ASSEMBLY CASTINGS

The principal casting of the crankcase assembly is the crankcase. The first crankcases were designed from experience on the large, heavy crankcases then being made. In general, the loads were carried by the walls and bulkheads. Bosses were put wherever needed to accommodate bolts, studs, oil holes, bearings, etc., and the size of these bosses were limited to the minimum needed. This design was satisfactory during the early development of the engine when operating loads were low.

However, as the development of the engine progressed higher outputs were being obtained, and higher loads were being applied to the structure until failures, such as those shown on Figs. 5, 6 and 7

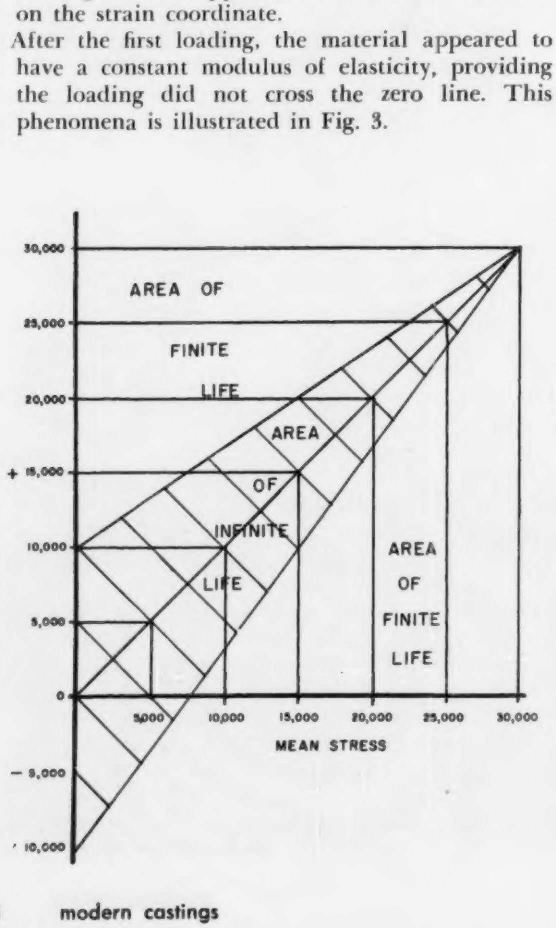


Fig. 4 — Goodman diagram for gray iron.

Fig. 5 — Crankcase failure during operation.

were experienced. The failures appeared to start at the junction of the main bearing capscrew boss and the main bearing bulkhead. Subsequent stress coat tests showed this to be an area of high stress, Fig. 8. Strain gage tests made under operating conditions showed that the working stress in this area increased with horsepower output.

At the high output, the working stress, when combined with the assembly stress was of sufficient magnitude to cause failure, when interpreted on the modified Goodman diagram, Fig. 9.

As a result of this experience, the design was modified so the loads and forces could be carried in as straight and direct a line as possible by bosses and ribs. The transitions in bosses and ribs were minimized, and the bosses around drilled passages were made as generous as possible. Figures 10 and 11 show stress coat results and Fig. 12 shows the strain gaging on the new design. Comparing Fig. 12 with Fig. 5, 6 and 7 makes the design change apparent. Static and dynamic tests showed that the redesign

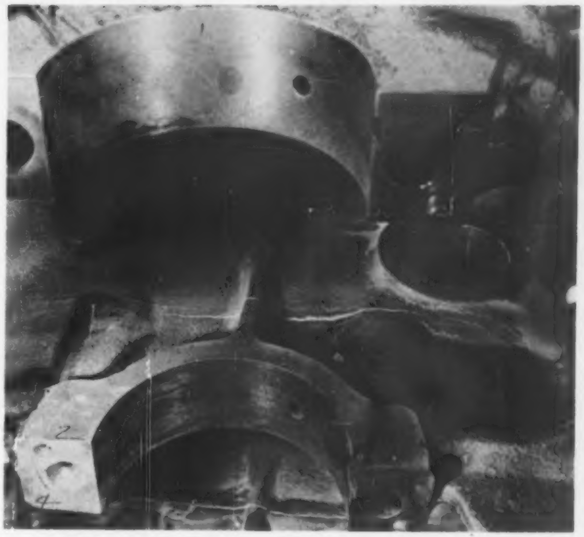


Fig. 6 — Crankcase failure during operation.

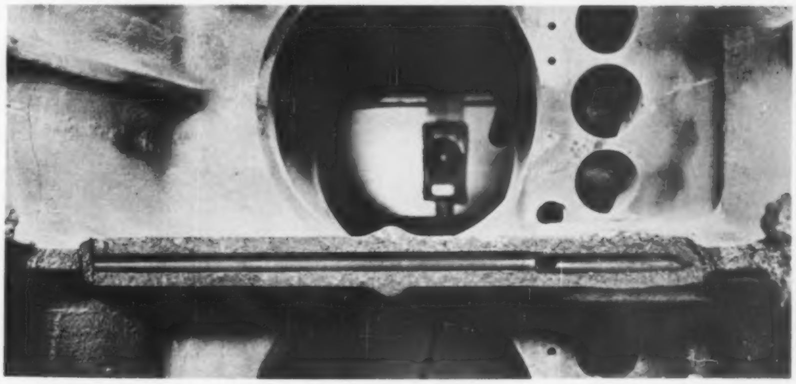


Fig. 7 — Failed section broken out of crankcase.

was satisfactory, and no further problems or failures were experienced in this area during development and final endurance testing prior to production release.

Production Castings Failure

However, when the engine was first built in production, failures were experienced, as shown on Figs. 13 and 14. Investigations showed the most significant change between development and production was the source of the crankcase castings. The production castings were obtained from a production foundry where large castings and small castings were made, so that a base iron was required that could be used on the extremes. Furthermore, manufacturing exerted considerable pressure on the foundry to assure castings that were easy to machine.

The drawings from engineering specified only a broad maximum and minimum hardness range, and there was nothing in the drawings to indicate that these castings required a material of a certain minimum fatigue strength in the critical areas.

The fatigue strength of the material in critical areas of these first crankcases was investigated, using

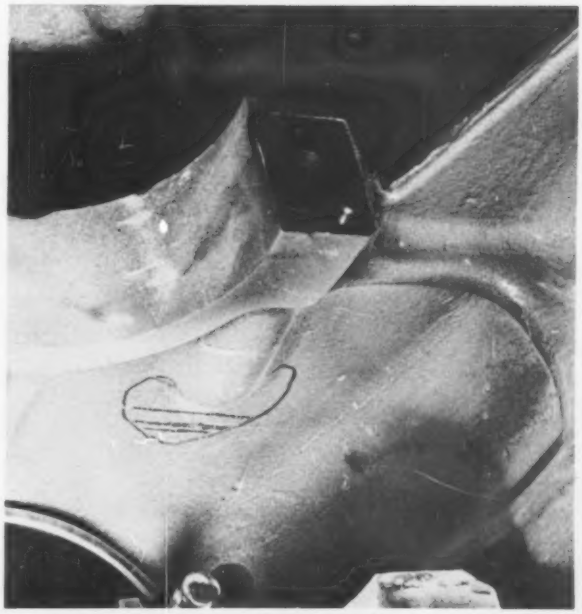


Fig. 8 — Stress coat pattern on crankcase.

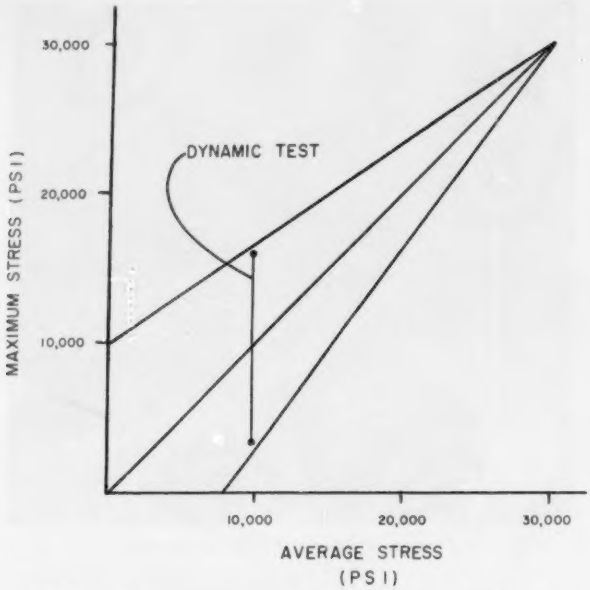


Fig. 9 — Goodman diagram for stresses in the failure area of crankcase casting.

Fig. 11 — Stress coat pattern on redesigned crankcase.

specimens of the design shown in Fig. 15. These specimen were made from the main bearing capscrew bosses and oil gallery bosses. The size was determined by the size of the boss, and the diameter was kept as close to the diameter of the boss as possible to minimize any size effect, which incidentally was found to be appreciable. It was found that the crankcases in this lot were made of a material whose fatigue strength was considerably lower than required. Also, the hardness in the critical area was low.

Therefore, meetings were held with personnel from the foundry, manufacturing and engineering. The requirements of the casting, and the effects of not meeting the requirements, were discussed from all viewpoints. Once the requirements were clearly known, the foundry, engineering and manufacturing were able to work as a team in order to meet the necessary requirements without any detrimental effect.

Investigations showed that although scatter does exist, hardness gives the best correlation to fatigue strength. Therefore, a minimum hardness was specified in the center main bearing area after removal of the casting skin. Equipment was installed in the foundry so this could be checked on a 100 per cent basis. Checks made by manufacturing on finished machined cases showed this was an excellent method of quality control.

The foundry also investigated many modifications in materials and casting practices until all the minimum requirements were met or exceeded. Among the notable items investigated was the effect of inoculations of tin, molybdenum, varying percentages of steel scrap in the melt, cooling time in the mold,

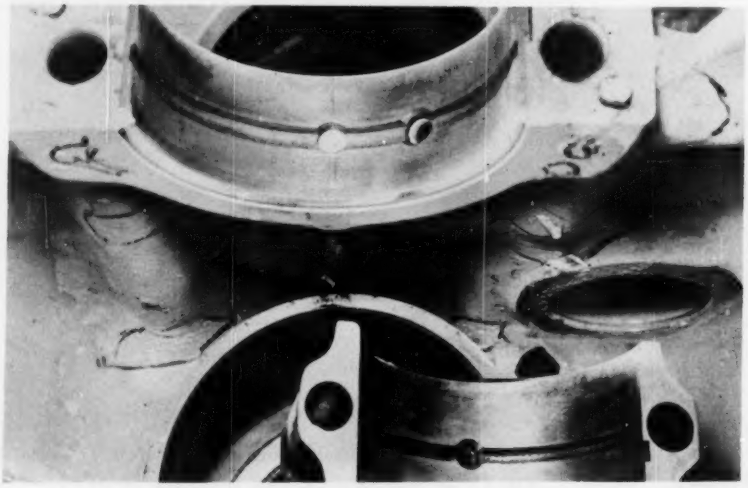


Fig. 10 — Stress coat pattern on redesigned crankcase.

Fig. 12 — Strain gage installation on redesigned crankcase.

Fig. 13 — Failure of redesigned crankcase.

Fig. 14 — Failed section from redesigned crankcase.

and means of minimizing residual stresses in the casting.

BEARING CAP CASTINGS

The original bearing caps were designed so that they could be cast in a cluster, and then cut into individual caps for machining, Fig. 16. Early in the development of the engine bearing cap failures were experienced, as shown in Fig. 17. Resorting to the "Add To" and "Beef It Up" manner of designing, the section modulus of the bearing cap across the area of failure was increased by more than 50 per cent. This change increased the weight of the cap by more than 20 per cent, and created a possible manufacturing problem because these bearing caps extended below the pan rail of the crankcase.

This heavier cap was found to have about the same life as the previous design, the failures being identical in appearance. Strain gages were installed in the failure area, and the stresses measured during various engine operations. It was found that the stresses increased with horsepower, and that the working stresses alone were not of sufficient magnitude to

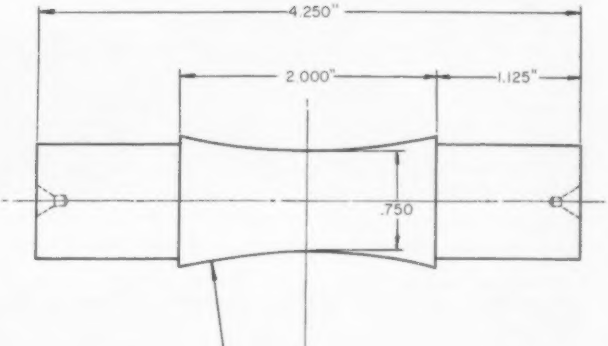


Fig. 15 — Modified SF-10-R fatigue test specimen for testing specimen taken from crankcase castings.

Fig. 16 — Original bearing cap.

cause failure. Additional tests showed that the assembly stress was high, and when the assembly stress was combined with the working stress, failure from fatigue could be expected.

The high assembly stress was a bending stress caused by unsymmetrical stiffness around the bearing cap capscrew bore. Increasing the section modulus, of course, did nothing to relieve this condition, and from the tests it was found that while this change did reduce the working stresses slightly the assembly stress was increased slightly, so no overall improvement was obtained.

A series of tests using stress coat was conducted, and areas of low stress and high stress were determined. These tests further verified that the high assembly stress was due to bending resulting from areas of unsymmetrical stiffness. Material was removed from the area of flow stress in such a manner as to make the stiffness around the bearing cap capscrew hole as symmetrical as possible. This reduced the weight by almost 20 per cent and increased the fatigue strength by 20 per cent. The effect of bearing cap design on bearing cap assembly stresses is graphically illustrated in Fig. 18.

The weight was further reduced by reducing the height of the bearing cap and changing the material to ductile iron. The combination design and material change increased the fatigue strength of the bearing cap to almost 40 per cent more than the original. A chart showing the relative designs with weights and safety factors is shown in Fig. 19. Figure 20 shows the bearing cap design evaluation.

CYLINDER LINER

The cylinder liner was also the subject of considerable experimental stress analysis work. Failures were obtained, as shown on Fig. 21, with the hours to failure being relatively few hours. Stress coat tests showed that the forces from the cylinder head assembly caused patterns in the fillet below the pilot bore,

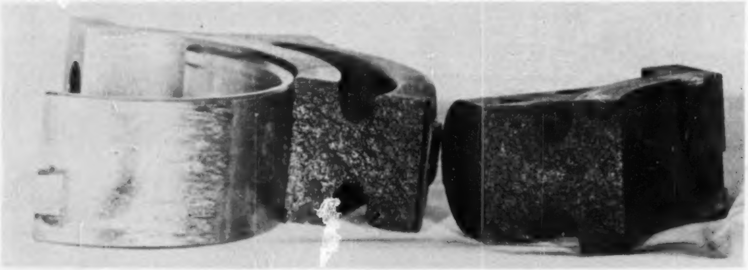


Fig. 17 — Bearing cap failure during operation.

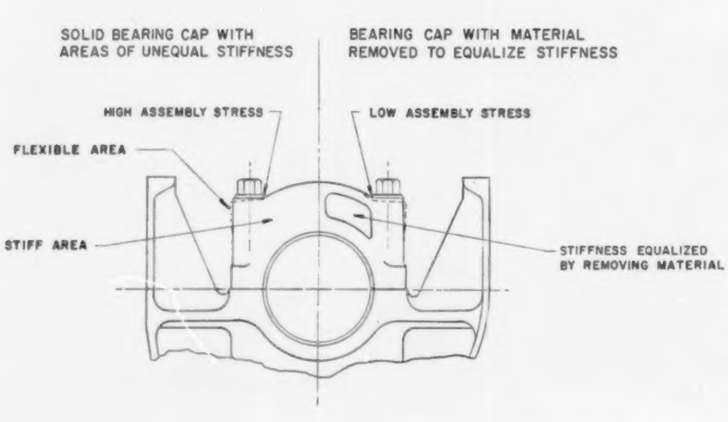


Fig. 18 — Bearing cap design effect on assembly stress.

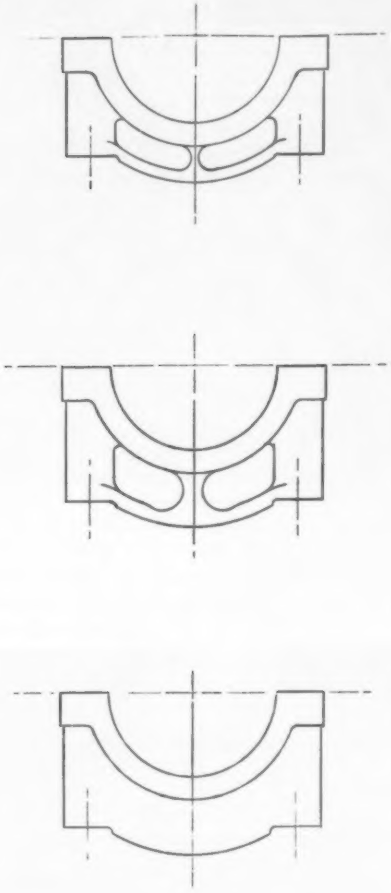


Fig. 19 — Comparable strength of main bearing caps. *Top* — old production (C.I.) — wt. — 10.37 lb. Safety factor — 1.02. *Center* — revised old production (C.I.) — wt. — 8.614 lb. Safety factor — 1.22. *Bottom* — present production (D.I.) — wt. — 7.915 lb. Safety factor — 1.40.

in the area aligned with the long studs on the camshaft side of the engine. This area was also where the predominance of operating failures occurred, indicating that the assembly stress contributed to the observed failures, Fig. 22.

Strain gages were installed on a cylinder liner which was installed in an engine, and readings taken under operation. The strain gages were installed to measure both the longitudinal strain and the hoop strain. Typical oscillograms taken from these tests showed that the assembly stress was the minimum stress, that the working stress increased with horsepower and that hoop strains were of about the same magnitude as the longitudinal strains. The strains recordings on the oscillograph closely resembled firing pressure recordings.

A static test set up in which the crankcase, sleeve, crankshaft, cylinder head, piston and connecting rod were assembled as in an operating engine. The piston was reworked to accommodate an O-ring, so that the firing pressure could be simulated by hydraulic pressure acting on the piston. It was found the results obtained on the static tests were similar to the results obtained on the dynamic test in the operating engine, and the balance of the test work was done under static conditions.

In general, the tests showed that the assembly loads and the firing pressure caused the sleeve to bend, as shown in Fig. 23. The assembly loads effected mainly the stresses in the longitudinal direction, and had little effect on the hoop strains. The firing pressure, however, affected the stresses in both the longitudinal and hoop direction causing a bi-axial stress condition. The hoop stress is generally the most critical in a cylinder under pressure. However, because of the effect of assembly loads on the longitudinal strains, the failure actually started in the longitudinal direction.

Proposed Solutions

Since the mechanism of failure was known, many solutions to the problem presented themselves. Some of the proposed solutions included reducing the assembly torque, reducing the firing pressure, changing to a better material, shot peening the failure area,

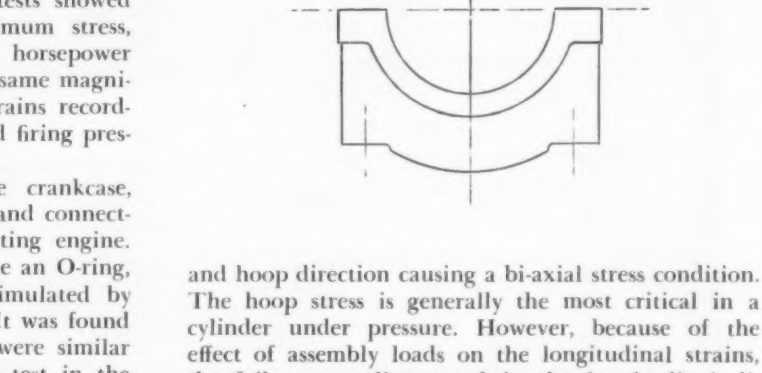


Fig. 20 — Evolution of bearing cap design.

Fig. 21 — Cylinder liner failure from operation.

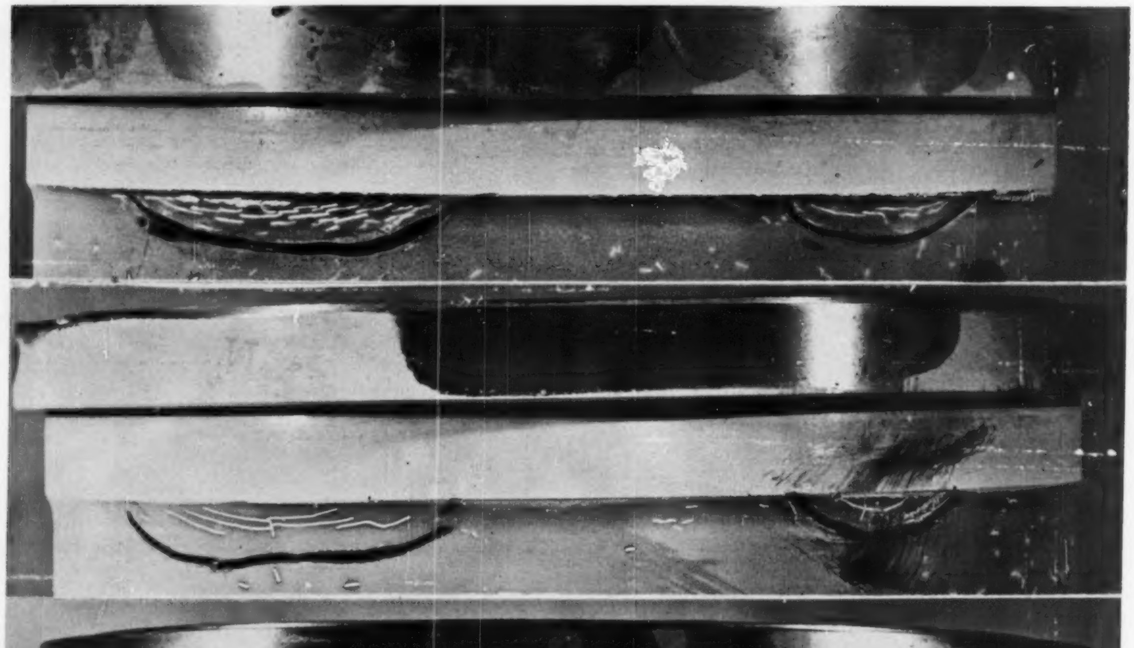
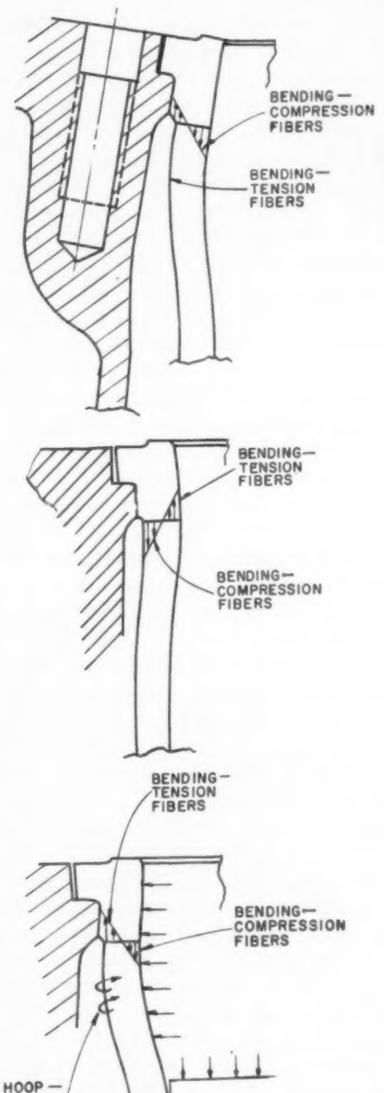


Fig. 22 — Stress coat patterns on cylinder liner. Cracks line up with large studs.

Fig. 23 — Mechanism of loading on cylinder liner (greatly exaggerated).

Sleeve deformation due to tightening torque (section at stud).
Sleeve deformation due to tightening torque (section between studs).
Sleeve deformation due to hydraulic loading (section at and between studs).



increasing the section modulus in the failure area or just increasing the support against bending. The simplest of all the proposals was to increase the support against bending, as this could be accomplished by simply reducing the clearance between the crankcase bore and the cylinder sleeve pilot.

The modified Goodman diagram in Fig. 24 shows that the safety factor increased from less than one to slightly under 1.2 by this change.

Experience to date has shown that the corrective measures made on the basis of these analyses presented has been successful. To date, with the engines that have operated in the field, some for many thousands of hours, no failures have been reported in the areas discussed. This, of course, has given a great deal of confidence in the experimental stress analysis techniques and methods, so that the thinking of management has changed.

Today, stress work is started when the first pieces are made, so that structural development parallels the performance development. In the past, stress work was conducted only after failures were experienced under operation. Furthermore, the lessons learned are being applied to new designs so that less mistakes are made on the first pieces and less corrections have to be made, since the principles of good design in gray iron castings are made readily apparent.

SUMMARY

Some of the lessons learned from these experiences are:

1. Carry loads through members loaded principally in tension or compression, preferably in compression.
2. Avoid carrying any loads in bending.
3. Do not neglect the effect of assembly stresses.
4. Determine material properties by specimen made from the casting.
5. The modified Goodman diagram is an excellent means of analyzing a structural assembly under operating loads.
6. Work closely with the foundry so they will know where critical areas are, and what is required in the critical area.
7. Locate material controls such as hardness specifications in critical areas where the material properties are important.
8. Castings are not made stronger by making them heavier.

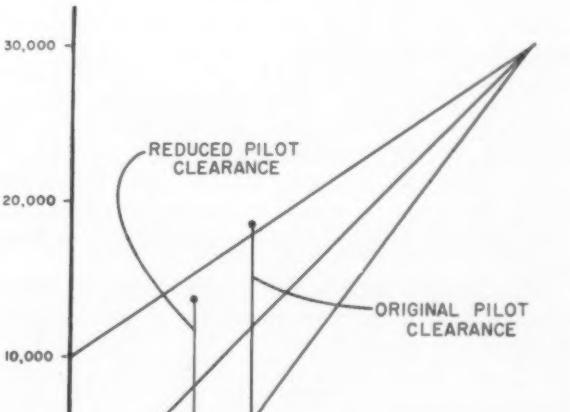


Fig. 24 — Modified Goodman diagram for maximum sleeve stresses combined by $\sigma_{MAX.} = \frac{E}{1 - r^2} (\epsilon_x + \epsilon_y \mu)$ $E = 14 \times 10^6$. 2100 psi pressure.

LADLE REFRACTORY PERFORMANCE IMPROVEMENT TEST PROGRAM

by P. J. Neff, J. J. Downs and J. T. Baker

ABSTRACT

Necessary increases in the temperature of metal disclosed inadequate performance of refractories commonly used in ladles. A program of testing and evaluation has revealed that such materials have little or no reserve capability to withstand increases in temperature. Magnesite furnishes this reserve for nozzles. All other refractories in the ladle are improved by the use of materials containing alumina in amounts considerably higher than are ordinarily used. The higher initial cost is justified by a reduction in cost per ton poured and by an improvement in the pouring operation.

INTRODUCTION

The ladle refractories and methods of application used at the authors' company for many years conformed to the standards generally accepted by the industry. Such practice had served reasonably well under the conditions prevailing at that time. Changes in production methods made an increase in metal temperatures desirable. They were increased approximately 150 F from the former level of 2800 to 2850 F (1538 to 1566 C). It is well known that such temperatures alone are sufficiently high to cause rapid deterioration of fireclay refractories. Additional problems arose because of more rapid attack by the furnace slag.

All melting is done in basic lined electric furnaces. The resulting slags have analyses that generally lie within the ranges of:

	Analysis, %
CaO	40 - 50
SiO_2	10 - 20
FeO	2 - 10
MgO	4 - 15
MnO	5 - 10
Al_2O_3	2 - 7
P_2O_5	0.1 -0.5

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The high percentage of CaO is, of course, the principle reason for attack on clay refractories.

The ladles are all of the bottom pour type having nominal capacities of either 5 or 10 tons. As indicated by production schedules, the lining may be altered to change the ladle capacity. For example, the 5 ton ladles have at times been lined to hold 3 tons. All the ladles are brick-lined, as shown in Fig. 1. Included in this drawing are the other refractory parts of the ladle to be discussed separately.

In the main, the work that has been done to improve the performance of ladles can be divided into two categories. The first including nozzles, stoppers and sleeves directly affected the capability of pouring the heat and obviously influenced such matters as metal losses and casting quality. The performance of these parts is influenced by the fact that there may be as many as 230 openings in a heat. The second was concerned more with extending the life of the ladle lining for economic reasons, not only to equal the former performance but to substantially improve it.

NOZZLES

Nozzles generally used in bottom pour ladles are of the fireclay type, although references can be found on zircon, magnesite and a few other variations. It seems that two virtues have been ascribed to fireclay nozzles. The first and most obvious is their low cost. The second, while more obscure, is apparently considered to be of great importance by many. This is the capability of the nozzle to soften at high temperature and thus permit deformation by the stopper. In this manner leaks arising out of poor fits or caused by damage to the stopper during pouring can usually be controlled. While the combination of the soft nozzle and the hard stopper is almost historic, it should be obvious that such deformation and the attendant erosion of the nozzle must be accompanied by transfer of the eroded material to the metal stream and eventually into the product.

Some years ago this problem of nozzle erosion, especially with steel containing 1.5 per cent manganese, was recognized, and the use of an improved nozzle was adopted. While no attempt was made at that time to analyze the material, it was known that the clay had a higher alumina content. Experience showed that its resistance to erosion was improved, although deformation of the seat was common. With increased pouring temperatures, there was an immediate and severe increase in the amount of erosion of these nozzles.

This caused a notable increase in nonmetallic particles in the castings, and also led to a vast increase in metal losses. Most of these metal loses were attributed to the failure of the nozzle resulting from excessive erosion, although there were too many instances in which there was also some sort of a failure in the stopper. All the evidence at hand supported the point of view that the composition of the nozzle was such that it simply did not have the capability to withstand the higher temperatures. Softening of the material at these high temperatures, combined with the erosive effect of the steel, and particularly the manganese in the steel, led to failure. Thus, a need was indicated for a type of material which could better withstand these conditions.

Magnesite Nozzles

Of the several possibilities considered, the most obvious area for investigation was the use of magnesite. Magnesite nozzles are not new, and have been used for more or less specialized purposes for many years. A fair amount of information was available on this subject from one of the company's plants which had used magnesite nozzles for several years on certain heats. The only useful information available was that no erosion occurred during pouring, but that there was a prevalent tendency for the nozzles to leak. This was attributed to the inability of the nozzle to soften and form a perfect seat for the stopper.

Since it was most desirable to use a magnesite nozzle, consideration was given to steps which might be taken to eliminate the tendency for leakage. A number of design changes were proposed for the seat of the nozzle. For example, the conical seat, such as that used in an automobile valve to form a gas-tight seal, was considered. The common nozzle design and three other designs are shown in Fig. 2. The conventional or convex surface was rejected, since it already had a history of leakage. The conical surface was eventually rejected because it required a corresponding change in the design of the stopper.

The concave surface seemed to have the most promise. Mating of the stopper and nozzle surfaces with conventional practice is essentially on a line contact. With the inability of the nozzle to deform, there was speculation that the line bearing was not continuous and, therefore, permitted a small amount of leakage. The first design with a concave seat was such that the nozzle would conform over its entire top surface to the end of the stopper. Therefore, a large area contact would be presented. This was subsequently modified slightly, since it was foreseen that it would not be possible to consistently produce a concave surface of

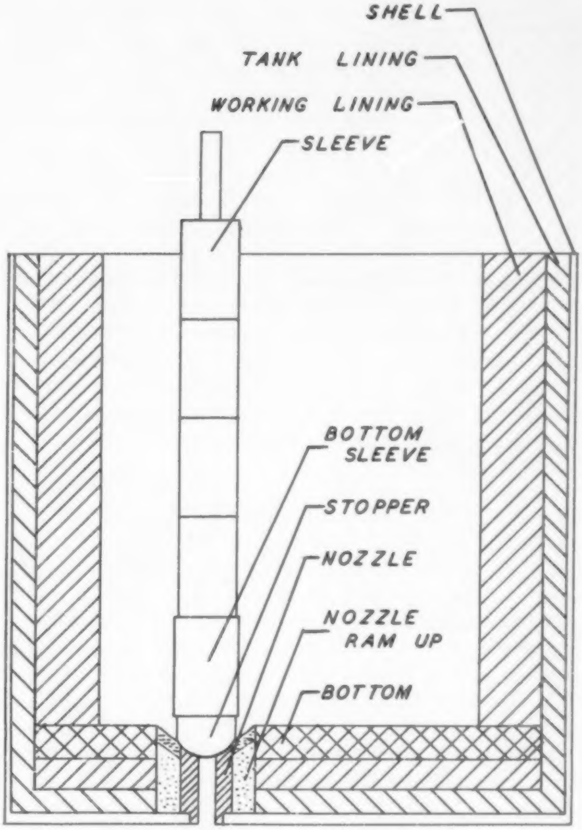

Fig. 1 — Construction of ladle.

sufficient accuracy. Therefore, the design was changed to increase the radius of the seat in the nozzle so that there would be some clearance.

A mold was built for making magnesite nozzles of this design, and samples were made and tested in production. In the initial trials, sand used during testing prior to tapping of the heat was allowed to remain in the small clearance groove around the side of the stopper. It was initially feared that the first metal into the ladle would fill this groove, and because of the high conductivity of the nozzle would freeze in place thus interfering with subsequent performance. It was later found that the use of sand in this area was unnecessary.

Nozzles with 1½-in. holes are used exclusively. However, a few one in. nozzles were tried but were abandoned, because of the tendency to freeze during pouring. This was attributed to the high conductivity of the magnesite. Thus, it may be possible that less satisfactory performance could occur at lower metal temperatures.

Chemically Bonded Magnesite Nozzles

The nozzles that are now used are made of chemically bonded unburned magnesite. While this material has shown inadequate performance in other parts of the ladle, performance in nozzles has been excellent. Erosion, for practical purposes, is nonexistent, and there is no deformation of the seat during pouring

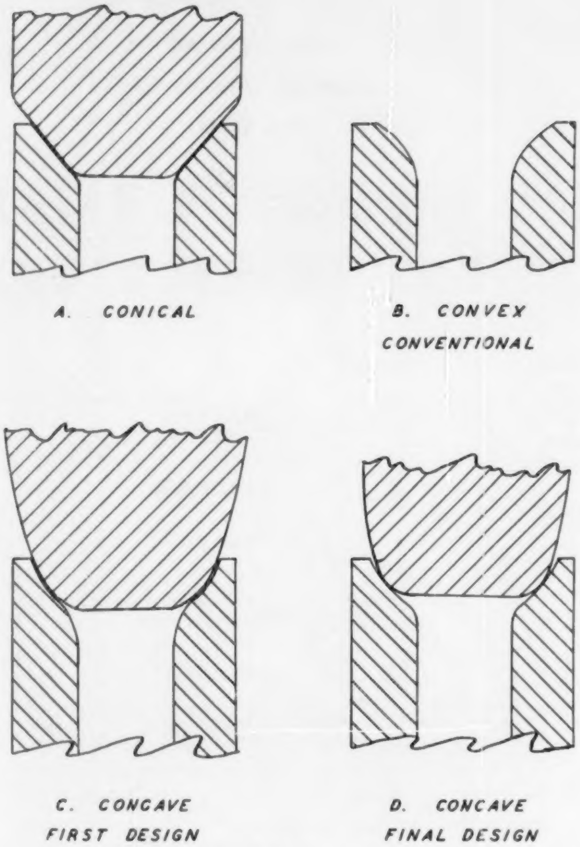

Fig. 2 — Design of nozzles.

heats under any conditions. There is no problem with cracking or spalling.

Contrary to the experience reported by others in pouring carbon and low alloy steels, there is no evidence of any buildup in the flow hole of the nozzle. Such buildup has been attributed by others to the use of aluminum in the steel, leading to a successive reduction in the diameter of the flow hole to the point where pouring of the steel is seriously impeded. There is information also presented in the literature advocating strict adherence to certain design principles in nozzles among, which is the requirement for a convex-shaped seat to produce streamline flow of metal through the nozzle. Seemingly in contradiction of these principles, the concave nozzle seat has consistently produced a smooth flowing stream.

There is little tendency for the metal stream to waver or to form an umbrella. Having arrived at the design as previously described and resorting to the use of magnesite as a material, no further changes have been undertaken in the nozzle. This design of magnesite nozzle has been used on all heats ever since it was first produced. During its use, covering a period of several years, there are no known instances of failure during pouring which could be attributed to the nozzle. Unfortunately, the successful use of magnesite nozzles did not eliminate metal losses. On the other hand, it disclosed more clearly the fact that stoppers were equally at fault and warranted intensive investigation.

NOZZLE WELL RAM-UP MATERIAL

After the use of magnesite nozzles became standard practice, it was evident that a large amount of erosion of the nozzle well ram-up material occurred. The material normally used at that time was a clay graphite mixture. After dumping the slag from the ladle, the nozzle would protrude above the nozzle well ram-up material. This was not noticed when using the clay nozzles because they eroded at the same rate as the ram-up material. Figure 3 shows the nozzle well rammed with a clay graphite mix, and a magnesite nozzle showing this erosion. Because of the proximity of the nozzle well ram-up material to the nozzle, it is most likely that material eroded from this area would be carried into the molds.

Magnesite ramming mixes from two suppliers were tested. Both were superior in erosion resistance to the clay graphite mix. On the other hand, freshly prepared mixes dried rapidly and had to be used in

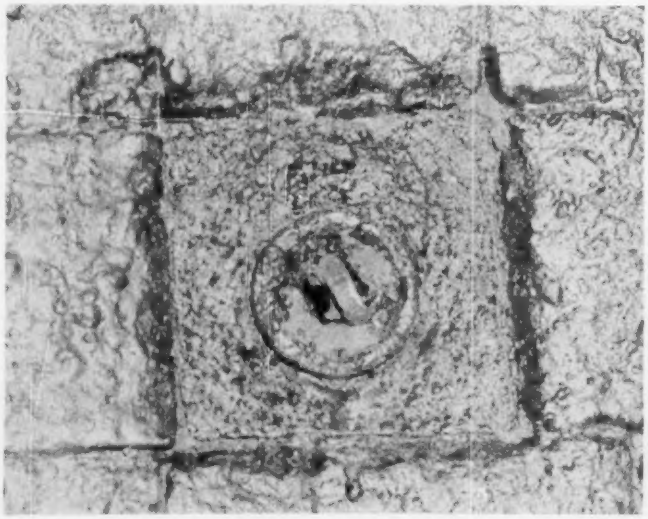

Fig. 3 — Erosion of clay graphite nozzle well ram-up from around a magnesite nozzle.

a short time. They were also more difficult to ram, and it was necessary to fire the mix immediately after ramming to prevent crumbling of the surface. For these reasons, other materials were tested.

A mullite ramming mix used in a nozzle well was found to have excellent erosion resistance. It was similar to the clay graphite mix in bench life and ease of ramming. Furthermore, it was not necessary to fire the nozzle well immediately after ramming. A sillimanite ramming mix was found to be superior to the clay graphite mix, but eroded more than the mullite ramming mix. The bench life and ramming characteristics were the same as the mullite mix. The mullite mix is used at the present time as the nozzle well ram-up material, and is applied as a 2 in. thick layer over a cheaper and less refractory base.

STOPPERS

While magnesite nozzles were not a cause of leakers, they did accentuate a condition that probably existed all along—a condition which was disguised by clay nozzles that softened in use. The clay graphite stopper heads were cracking, spalling and eroding and evidently were completely unable to withstand the elevated pouring temperatures. Magnesite nozzles do not soften in use as did the clay nozzles previously used; therefore, when a stopper spalls or erodes and loses its contour, the nozzle will not conform to the new shape and a leak results. As spalling and erosion continue, it becomes increasingly more difficult to attain a shut-off, and eventually, in some cases, the rest of the heat has to be pigged. Not only do these stopper failures cause metal losses and a safety hazard, but they act as a source of dirt in castings. A stopper was needed which would be more resistant to thermal shock, spalling and erosion. There was also a need for a method of testing stoppers without incurring the high metal losses, which could result if an experimental stopper were to fail in a production heat.

There is a standard thermal shock test used for refractories. This test consists of heating the sample to a high temperature in a gas-fired furnace followed by air cooling under closely controlled conditions. This procedure is repeated until the refractory in question spalls or cracks. The number of cycles to failure is recorded, and this number is the test result. While this test may be satisfactory for some refractory applications, it in no way exposes a piece of refractory to the conditions approaching those to which a stopper head would be subjected in use.

Under these conditions the head is rapidly heated to temperatures much higher than those used in the typical thermal shock test. At these temperatures it is repeatedly pressed into a nozzle while hot erosive metal flows around it. What was actually needed was a service condition test, one which could simulate the conditions to which a stopper head is subjected and one that could easily be run using available facilities. The facilities available were a number of standard heat treat furnaces and three induction melting furnaces. The induction melting furnaces offered the best possibility for a service condition test. In such a furnace, ladle conditions under which the stopper head must operate can most easily be duplicated.

To conduct such a test, the sample stopper is assembled on a rod with a normal stopper rod pin and plug mix. It is then dried and preheated to about 400 F. The head is suddenly immersed into molten steel at 3000 F and held for 5 min at that temperature with power on. This subjects the head to the same thermal shock as it would receive in a ladle. The induction action of the furnace washes metal around the head, duplicating the erosive conditions of pouring. The time period for which the head is held in the metal allows it to be uniformly heated throughout. The head is then removed and allowed to cool. Inspection of the stopper starts immediately upon removal from the furnace. Visual examination if done while hot, readily reveals spalling. After the head is cool, a closer examination not only shows the spalling but allows determination of cracking or erosion.

Stopper Failures

The head is then cross-sectioned transversely. This section is ground smooth and examined for various types of failures which are not necessarily visible on the surface. The effects of this test upon stopper heads are essentially the same as those observed in production heats. First, spalling is a common type of failure (Fig. 4). This is the type of flaking in which thin layers break away from the head, exposing a new surface. This new surface then is subjected to further spalling, and the head progressively disintegrates in this fashion until leaking or loss of remaining metal results. Any spalling at all will disqualify a head for a production trial.

The second type of failure is radial cracking (Fig. 5). Radial cracks usually occur at 120 degree intervals and split the head into three sections. This type of failure is considered to be more serious than spalling. Once the crack initiates it continues to widen, and leaking almost surely results. In severe cases, the heat is lost. The third type of failure commonly observed is erosion where material is washed away from the surface of the head by action of flowing metal (Fig. 6). Templates can be used to measure the degree of erosion.

Fig. 4 — Spalling of a stopper head.

Fig. 5 — Radial cracking in a stopper head.

All sample heads are tested in duplicate and both heads must pass the test in order to warrant a production trial. The test requires that the head does not spall or crack, and that erosion is at a minimum. Experience has shown that even a slight tendency to spall or crack in the thermal shock test will result in poor performance in a production heat.

Stopper Head Test Program

The failure of the clay graphite stopper heads which were being used marked the start of an intensive test program. At first many commercial heads from domestic suppliers were tested. These common heads contain about 12 per cent graphite. The ignited sample contains 60 per cent silica and approximately 35-37 per cent alumina. It was found that heads of this general composition spalled severely when shock tested, eroded rather readily and subsequently performed quite poorly under operating conditions.

When it became evident that a satisfactory head was not available, a number of special heads were produced on an experimental basis. Among the special mixes which were formulated and tested were—chemically bonded magnesite, magnesite chrome, burned chrome magnesite, high refractory clay without graphite, fused silica, periclase and mullite. All of these had a tendency to crack and break apart when tested and none was satisfactory.

A combination mullite graphite head was tested which was better than the heads formerly used, but not good enough to warrant use. A stopper head was obtained from a foreign supplier which contained 26 per cent graphite, 60 per cent alumina and 35 per cent silica, as determined on the ignited sample. Not only is the graphite much higher, but the percentages of alumina and silica are essentially the reverse of domestic stopper heads. The apparent density was 1.88. This particular head was practically inert when subjected to the thermal shock test. It did not spall or crack and erosion was nonexistent. Production trials of this type head gave excellent performance. It was subsequently adopted as part of the standard practice and became a standard of comparison for test purposes.

A large amount of test information leads to some conclusions on factors influencing the behavior of heads when subjected to a thermal shock test. The first of these factors is composition of the head. Tests to date show a correlation between spalling tendency and silica content. High silica is conducive to spalling, and it follows that the higher the silica content the more severe is the degree of spalling. As silica decreases from approximately 60 down to 40 per cent, the severity of spalling decreases proportionately un-

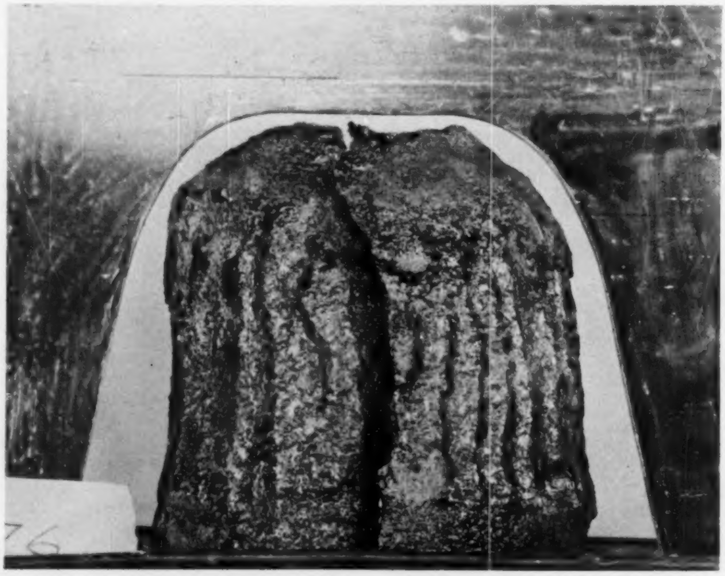

Fig. 6 — Eroded stopper head.

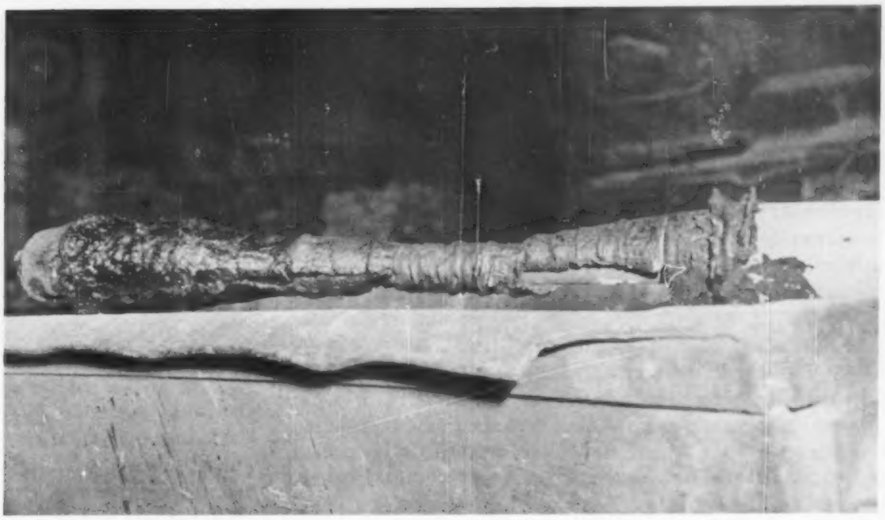

Fig. 7 — Badly eroded stopper rod sleeves.

til it disappears at approximately 34-40 per cent SiO_2. The alumina, which should make up the balance of the mix, adds to refractoriness, and seems to increase resistance to erosion.

The function of the graphite is not clear, but it apparently influences heat conductivity, thus affecting thermal expansion, a major cause of spalling and cracking. It may also influence density, the other major property affecting performance of the heads. Density may be affected not only by graphite content but also by the method of forming and firing of the heads. High density leads to radial cracking, even if alumina and silica contents are in the desired range. An experimental head was tested which had the proper amount of alumina and silica but was low in graphite and had an extremely high density of 2.18. This head showed little erosion and no spalling, but it did crack radially.

All tests to date indicate that the optimum composition for the stopper heads is one containing 25 per cent graphite and 75 per cent clay which, in turn, is composed of approximately 60 per cent alumina and 35 per cent SiO_2. Optimum density is around 1.88. It has also been observed that a fine grain size of the refractory particles is desirable if optimum properties are to be developed.

STOPPER ROD SLEEVES

With increased metal temperatures the erosive effect of basic slag on common clay stopper rod sleeves created an intolerable situation. This was especially true with steels containing manganese in the range of 1.5 per cent. Figure 7 shows such a rod assembly after use. In some cases sleeves eroded early enough to expose the rod to molten metal or to molten slag, causing failure of the rod and partial loss of the heat.

In a first attempt to obtain better performance, the common clay sleeves were replaced with sleeves which the supplier indicated had a higher PCE. It was presumed that this was achieved by an increase in the alumina content. The performance of these sleeves was essentially no better, and it was concluded that any changes the manufacturer may have made were not great enough to significantly alter the properties of the parts.

To withstand the attack of the basic slag it seemed reasonable to consider the use of a basic refractory. Accordingly, a number of chemically bonded magnesite sleeves were produced. Several of these sleeves were first subjected to immersion in molten steel in an induction furnace. Several heats were also poured from a 1000-lb bottom pour ladle. In these preliminary tests it appeared that the sleeves had good erosion resistance and did not spall. On this basis, several 9-ton heats were made.

The sleeves performed satisfactorily from a mechanical standpoint but were found to evolve large volumes of gas, presumably from decomposition of the material used for bonding. As a result, many of the castings poured in the heat contained an objectionable amount of porosity. It was found that this gas forming tendency could be eliminated by preheating the sleeves to 1400 F (760 C) before use. Inasmuch as this involved an extra operation, it was not considered practical.

Chrome magnesite sleeves were found to have good resistance to erosion and spalling and were used in production for a short time. However, they developed a tendency to crack, allowing metal to penetrate to the rod. This tendency to crack seemed to become worse as the age of the sleeves increased. In general, the overall results obtained when using sleeves made of basic materials was unsatisfactory.

Alumina Content Variation

Attention was then directed to the consideration of materials containing more alumina than is commonly used. Sleeves made of mullite, for instance, were found to have excellent resistance to erosion, and were practically immune to any signs of spalling or cracking. An objectionable feature of the mullite sleeves was their much higher cost. A partial cost reduction was achieved by changing the design so that the diameter was reduced from 5½-in. to 4⅜-in. The capability for making such a reduction in diameter was directly attributable to the greatly improved resistance to erosion.

The larger diameter of the common clay sleeves was partly a concession to erosion, to insure that there would still be an adequate amount of refractory remaining at the end of the heat. In spite of the reduction in cost achieved by reducing the weight of the parts, the cost of the mullite sleeves was still prohibitively high. In view of their exceptional performance, it was believed that some reduction in the alumina content could be made without seriously affecting performance.

Sleeves were prepared containing alumina in amounts of 50 and 60 per cent, as compared with the 70 per cent present in mullite. These sleeves were less subject to erosion than the common clay sleeves, but were not as good as the mullite. It was found in a general way that the extent of erosion was essentially proportional to the amount of alumina in the refractory. Furthermore, the cost of the sleeves was also directly related to the alumina content. On this basis, it was found that sleeves containing 50 per cent alumina were adequate for production purposes.

While a substantial amount of erosion could occur during pouring, the wall thickness was sufficient to protect the rod throughout the heat. An exception was made in the case of the bottom sleeve. This sleeve covers the stopper, and it is imperative that no metal enter the joint between the stopper and the sleeve. If attack in this joint is too great there is the likelihood that the stopper rod pin may be melted. Sixty per cent alumina sleeves were found to give this added protection.

LADLE BOTTOMS

Prior to the requirement for improved ladle performance ladle bottoms were laid with brick containing 70 per cent alumina. The higher cost of this brick compared to more commonly used fireclay had been justified on the basis of a longer life. With the increased temperatures ladle bottoms deteriorated more rapidly. This was of concern not only in the consideration for the total life of the ladle, but also because of the increased likelihood that some eroded parts of the bottom could be carried into the castings.

A single attempt was made to construct a ladle bottom of magnesite brick; however, this brick cracked and spalled so severely after three heats that it had to be replaced.

Attention was, therefore, directed to the use of a monolithic lining for the bottom of the ladle. Rammed magnesite, which was considered a likely material to resist attack of the slag, gave a poor performance. Deep cracks were present after the first heat. Even though they were patched, the cracks were so enlarged after a second heat that the bottom had to be replaced. This failure was attributed partially to the alternate heating and cooling of the ladle bottom heats. Conceivably improved performance might be obtained if the ladle could be continuously maintained at a high temperature.

An attempt was also made to construct a similar type of bottom using a calcium aluminate cement. This material had given excellent results when used to line 1000 lb ladles; however, in a manner similar to the magnesite, the lining cracked severely after five heats and allowed metal to run under it. At first, cracking was attributed to damage incurred during removal of the nozzles, therefore, the test was repeated with the nozzle well surrounded with brick. This lining cracked in a manner identical to the first lining.

Although there is some consideration still being given to the use of a monolithic lining, this type of bottom has not been explored any further. On the other hand, brick with alumina content greater than 70 per cent is being actively investigated.

LADLE LININGS

The increased metal temperatures and the greater activity of the basic slag effectively caused a marked reduction in the life of the clay ladle linings. Prior to attempts to improve the life of the linings, the sidewalls were lined with hard burned clay brick containing 36 per cent Al_2O_3 and 58 per cent SiO_2. For some time these brick had been obtained in a cupola block shape as a means of reducing the number of brick joints from what would be required when using arch brick. With the increased temperatures the life of the lining was reduced from 13 heats to more than seven heats. While several different sized ladles were used at one time or another, most work done in evaluating performance of sidewalls was done on 5 ton ladles.

The method of testing and evaluating bricks varied as experience was gained. Initially, a number of types of brick were tested by installing a complete lining. It was quickly found that a given type of brick would not necessarily perform as anticipated, and in view of the markedly higher cost of some of the bricks that were used the cost of testing an entire lining could be prohibitively high. As a result, the use of patch tests was undertaken. The literature on refractories deals to some extent with the use of patch tests and several techniques have been described.

One method suggests that such a patch should extend all the way from the top to the bottom of the ladle, so that erosion products from the upper portion will not wash down over a test section and, therefore, produce erroneous interpretations. On the other hand, in some cases the amount of brick available for such a test would not have permitted such an extensive patch. Therefore, the general technique used involved the installation of a patch approximately 15 to 20 in. square about half way up the sidewall of the ladle. In general, this could be accomplished with two courses of arch brick, each containing about five brick.

These test pieces were installed in the sidewalls of ladles made up with brick that was considered standard at the time. In some instances, at the conclusion of a test, when it became necessary to discontinue the use of a ladle because of sidewall wear the test panel would protrude from the working face of the ladle a distance of several inches. It was possible to roughly measure the amount of erosion, and thereby extrapolate to estimate what the life would have been with an entire lining of the test material. Such a technique permitted the screening of a larger number of samples without the need for lining entire ladles.

It also permitted the testing of two or three different materials in a single ladle, thereby greatly speeding up the rate at which tests could be conducted. Obviously, the more promising of these test materials could then be used for producing complete linings.

Basic Brick Tests

Since attack of the basic slag on the clay brick was the principle reason for early deterioration of ladle linings, a number of basic brick shapes were tested. Forsterite (magnesium silicate) and chrome magnesite were tested in full linings. Severe spalling with both types of brick made it necessary to remove the lining from service after about 13 heats. Thus, although the ladle life was essentially doubled, the higher cost of the brick did not justify their use. Such spalling, in the main, was found to be almost a common characteristic of the basic brick that were tested. The lining, in general, performed quite satisfactorily for the first few heats, although there was a tendency for slag to adhere.

This adherence of the basic slag has been attributed to an increase in the melting point of this slag caused by a pick up of MgO from the ladle lining. If an attempt was made to remove the slag in cleaning the ladle, separation did not occur at the slag-brick interface but at some distance in the brick itself. Even though no attempt would be made to mechanically remove the slag, it would subsequently spall spontaneously and remove a substantial part of the brick at the same time. In the main, similar results were obtained on patch tests with burned magnesite, burned and unburned magnesite chrome, chrome and pure magnesite brick.

In view of the generally unacceptable results with basic materials, attention was directed to the use of materials containing higher percentages of alumina. Brick of this type is not subject to spalling or the buildup of slag that occurred with the basic materials, although their use did expose a problem in method of installation and the effect of brick joints. When it was found necessary to discontinue a test on a lining of 80 per cent alumina brick because of rapid failure at the brick joints, the method of installation was reviewed.

It was found that the practice in general use included a mortar joint generally ¼-in. thick, and in some instances as much as ½-in. thick. Rapid erosion at the corners of the brick and penetration into the mortar caused premature failure. The practice was changed to drastically reduce the amount of mortar, and to change its consistency to that of a slurry to permit laying the brick with as small a joint as possible. The effect on the performance of subsequent ladles was drastically improved.

70 Per Cent Alumina Brick

The most promising results and the quickest increase in ladle life were achieved with the use of 70 per cent alumina brick using the cupola block shape. The life of such a lining was 26 heats, or an increase of more than four times that obtained with the regular clay cupola block. Although the initial cost of this lining was higher than that of the clay brick, the extended life reduced the lining cost per ton of metal to a justifiable level. As a result, the 70 per cent alumina brick was adopted as a standard to replace the hard burned clay. Such cost studies as were made were based on the direct labor for relining a ladle and the cost of materials used. A saving more difficult to evaluate was the greatly reduced rate of relining achieved by the increased life.

Mullite brick was also tested and was found to perform well; however, at the time it was not felt that the higher cost could be justified. Their excellent resistance to slag might suggest their use in the slag line area of the ladle, which is subject to the most vigorous attack.

A number of other bricks containing high alumina contents (up to 85 per cent) have been tested and have all performed well. Obviously, the increased life of the ladle must be of sufficient magnitude to justify the expense. For instance, the cost of lining a ladle with a brick containing 85 per cent alumina would require at least 45 heats in order to justify use of the brick. A recent ladle lined with this brick was used to pour 60 heats before it was retired from service. At this time additional ladles have been lined with 85 per cent alumina brick, since it is obvious that they would be more economical in the long run.

In order to keep pace with improved performance of bricks, it was necessary to make comparative studies of several different available brick mortars. In general, these were tested by using different mortars in different sections of a given ladle. The brick joints were then examined after each heat to obtain a comparative measurement of any undercutting that might occur. Of the several mortars tested, it has been found that there is little difference in their performance; however, all of the mortars that have been used in the ladles containing high alumina brick are those mortars with high alumina contents.

In general, the experience gained with the brick linings and with mortars used has paralleled experience in other parts of the ladle, i.e., that the high alumina refractories are significantly more resistant to attack by slag, and can presumably be used to extend the life of the ladle and reduce the likelihood of failure.

Experience gained in this work has shown that materials seemingly similar do not necessarily perform alike. Nor is there assurance that successive shipments of a single item will be alike. Thus, there is indication of the desirability of a test program so that individual shipments can be carefully checked to ascertain their quality level.

ACKNOWLEDGMENT

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MAINTENANCE MATERIALS CONTROL SYSTEMS

by K. M. Smith

ABSTRACT

The maintenance management viewpoint of how maintenance material control systems and material disbursing systems can best serve maintenance department needs and at the same time help a company achieve low production costs is presented. The steps leading to an adequate evaluation of need for each item is outlined, and details of crib arrangement and operation are discussed.

BACKGROUND KNOWLEDGE

Inventory items can be more properly controlled if these points of background knowledge have been adequately developed:

1. Materials and parts that may be required.
2. Approximate quantity of each item in use.
3. Past usage or expected future usage of each item.
4. Purchase cost of each item, and yearly cost per inventory dollar for each type of item.
5. Normal and emergency sources of each item.
6. Normal and emergency procurement times and additional emergency procurement costs.
7. Equipment downtime costs per hour, shift or day that the equipment is not available for production use.

Steps to Knowledge

1. Identify all equipment. Each item of production equipment, as well as plant equipment, such as heating units, fans, valves, power sweepers, cranes, hoists, pumps and transformers, should be given an identifying number and name. This identifying number and name can be an embossed or stamped tag or plate, a painted legend, a decal or an adhesive label. Pipe lines should be identified by contents or service.

2. Set up equipment record folders. A separate equipment record folder should be setup for each equipment item or equipment category. Items such as electric drills, valves and pipeline classes are best handled in category folders, except for specialized items best kept in separate folders.

3. Collect a full set of information. On each equipment item there is need for full information. This information should be placed in the equipment record folder.

1. Make an index sheet for the contents of each folder to expedite the finding of the information contained in the folder, and also to serve as a reference means of replacing lost data, drawings, instruction sheets, etc.
2. List all drawings relating to a machine or equipment item and indicate the ones to be kept in the folder.
3. Make up basic and special data sheets on each equipment item.
4. Obtain a full set of operator's manuals for all cases where they exist. Study of these manuals provides a better understanding of the probable maintenance needs of a machine.
5. Obtain a full set of spare parts books or spare parts drawings for each equipment item. Do not overlook spare parts sheets for the electrical control items such as motor starters, disconnect switches, relays, limit switches, timers, etc.
6. Review spare parts books and drawings for completeness of the description of each part. Commercially available items such as bearings, seals, O-rings, couplings, roller chain, sprockets, electrical relays, brakes, should be completely identified so they can be purchased from the most economically convenient source.
7. Obtain a full set of electrical and hydraulic systems diagrams.
8. Obtain all other machine drawings that may be of value in repairing the machine.
9. Wherever practical obtain photographs or overall illustrations of the machine or equipment item.

4. Make out a job ticket for each maintenance job performed. When the job is completed, information on what work was done and how many of what parts were used should be added to the job ticket before the ticket is filed in the equipment record folder, unless other adequate information systems are already in use. Parts usage information will be helpful in determining minimum stock quantities. The job ticket should also show the date and the actual time required to do the job.

5. Determine probable need for spare parts and materials. Study the past parts requirements of each machine or of similar equipment, and develop a list of the parts and materials likely to be needed. The list may be made up by marking the spare parts lists and drawings or by making up a separate list. In some cases useful information will be available in the recommended spares list supplied by some manufacturers.

Determine the maximum number of any part that is expected to be essential for a repair job that cannot be reliably planned far enough in advance to allow for the purchase of the needed amount of materials.

Determine the approximate total installed quantity of each part.

Determine the past usage of each part or estimate the future usage of parts by comparisons with the history of known parts and machines.

6. Establish the yearly cost for each inventory dol-

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lar. A cost should be established for each class of material kept in inventory. This cost should be shown as per cent per year per dollar. This yearly cost should allow for interest charges, insurance, taxes, obsolescence, losses from theft and from handling of material, type and amount of material protection required and cost of storage space for each class of material.

For example, many unmachined castings, stainless steel castings and many barrelled products can be stored outside for long periods without serious damage. Other products can be kept in unheated dry storage, and machined parts are most safely kept in heated storage areas. Small parts will be kept in drawers, in bins or on shelves. Some materials can be stored as stacked pallets, and other materials must be kept in single pallets or as single layer storage in bins.

Avoid the temptation to lump together all inventory costs to obtain an average cost per dollar, because doing so will improperly burden small parts, many complicated machined parts and fragile items such as electronic tubes.

7. Determine materials sources and procurement details. Determine (a) the regular and emergency sources of each spare item, (b) the normal procurement time including order placing time, manufacturing time, shipping time and receiving and delivery time within the purchaser's plant, (c) emergency procurement time and (d) additional emergency procurement costs such as air express and special handling charges, and overtime charges by manufacturer.

In general the parts fabricated by the equipment manufacturer will only be available from that manufacturer. However, most manufacturers use commercially available bearings, oil seals, O-rings, bolts, belts, lubricating devices, pipe fittings, electrical components, fans, motors, pumps and hydraulic equipment.

It is advisable to determine the source or sources and full description of the commercial items, so that the replacement part to be used can be properly described in the individual spare parts book. This advance study of commercial items permits standardization of spare parts and establishes alternate sources of supply in case of emergency procurement.

8. Determine the total cost of each item. The list of potential spare parts for each machine should show the total cost of each item and the date for which each cost is correct. If special packaging charges, or substantial freight charges are involved but are not included in the price quoted by the vendor, the recorded cost should also show the approximate special charges.

A copy of the parts cost list should be kept in the machine record folder in each maintenance area to serve as a guide in determining the economy of repairing a part removed from service vs. the cost of buying a new part.

The inventory records for all parts which may be repairable should be marked in such a manner that a check is made with the proper maintenance supervisor before a new part is ordered.

9. Establish production downtime costs for each piece of equipment. A set of production downtime costs should be established for each machine or piece of equipment which could cause a loss of production in case of a failure. These costs should be shown as dollars per hour, dollars per production shift or dollars per day, depending upon the type of operation involved. If little loss occurs until the passage of a shift, a day or longer period of time, this fact should be shown. Where a machine is a part of a progressive line such that the shutdown of one machine causes losses by several machines, the dollar losses will be higher than for a separate machine installation. Thus progressive line installation should be noted on the downtime cost records.

It is suggested that the downtime costs be evaluated for conditions of low, medium and high rate of production operations. These downtime costs should be shown (a) in the equipment record folders and (b) in an index of equipment so arranged that comparative downtime cost comparisons can be conveniently made. The date applicable to each downtime cost should also be shown in the records.

CHOOSING INVENTORY STOCK ITEMS

Two categories of items are involved in determining what should be kept in inventory. One category consists of those items not now in stock, but which are potentially desirable stock items. The second category consists of those parts currently in stock, and which should be evaluated in terms of need for greater stock quantity, smaller stock quantity or zero stock. The evaluation methods are similar for both categories up to the point that surplus stock of an item is evident. Disposal of surplus inventory will be discussed separately.

For infrequently used parts the cumulative cost of holding a part in inventory for multiple years should be known. The table shows the actual charge accumulated against each dollar of initial inventory cost at various annual charge rates compounded semiannually for holding periods of up to ten years. When comparing downtime costs with inventory costs, the cost of a rarely used part held in inventory is the accumulated cost, not the original cost. The table makes no allowance for dollar inflation or for the possible price increase on parts for obsolete equipment.

CUMULATIVE FINAL COST PER DOLLAR OF ORIGINAL COST FOR ITEMS KEPT IN INVENTORY FOR MULTIPLE YEARS

Kept in Inventory Until End of Year Shown	Annual Charge Rate — Compounded Semi-Annually, $					
	8%	10%	15%	20%	25%	30%
1	1.08	1.10	1.16	1.21	1.27	1.32
2	1.17	1.22	1.35	1.47	1.60	1.75
3	1.27	1.35	1.54	1.77	2.03	2.31
4	1.36	1.48	1.78	2.14	2.56	3.06
5	1.48	1.63	2.06	2.59	3.25	4.05
6	1.60	1.80	2.38	3.14	4.11	5.35
7	1.73	1.98	2.75	3.80	5.20	7.08
8	1.87	2.17	3.18	4.60	6.59	9.35
9	2.05	2.41	3.68	5.56	8.34	12.40
10	2.19	2.66	4.25	6.73	10.55	16.40

10. Determine the practicality of and the cost of immediate repair of each part. If a part is expected to fail by breakage, can the part be welded quickly

and successfully? If the part is expected to be replaced because of wear, can the part be repaired quickly? In many cases worn parts can be detected soon enough to plan for suitable repair during a nonproduction shift.

Once the possibility of repair, the downtime required and the cost of repair are known, the total of the repair costs plus the downtime cost can be compared with the inventory cost of a new part. If repairing the part provides the lowest cost, no inventory should be kept. If a part needs to be kept in inventory, it can be a repaired part if the repair costs are less than the cost of a new part.

Warning — A crib full of repaired parts not kept in dollar inventory may increase the total storage costs normally charged entirely to the new parts kept in dollar inventory. Perhaps required parts should be kept on or at the machine using the parts, although this decreases the reliability of having adequate spares.

11. Determine the possibility of substituting another part on a permanent or temporary basis. Determining in advance that a single part will serve satisfactorily in more than one installation permits a smaller number of dollars in inventory to give greater protection against downtime losses. An adequate description of the substitute part to be used, and any unusual conversion procedures to be followed, should be clearly indicated in the parts list for the machine.

If a part is to be used on a temporary basis and then be returned to inventory, it will be necessary to flag the inventory record to show where the part is being used in order to avoid the purchase of another new part for the inventory. It is suggested that the records for the machine, which normally requires the part in temporary use elsewhere, should be marked to indicate that such usage may take place and where it may take place.

12. Compare downtime cost of immediate local purchase vs. inventory costs if part is kept in stock. Many items such as bearings, belts, couplings, sheaves and electric controls can be obtained from local sources within a few hours time, if proper advance arrangements have been made for quick procurement of emergency items. An alternate plan is to keep an emergency minimum stock which would be replenished by quick procurement methods. Quick procurement is desirable where the minimum stock protects a number of machines.

Since the actual or estimated parts usage should have been developed earlier, it can be readily determined if it is economically practical to keep a part in stock. The table will be helpful in determining the cost of keeping parts which are used infrequently.

13. Compare downtime cost plus extra costs of emergency purchasing vs. inventory costs if part is kept in stock. Before this method can be used, it must be determined that the part manufacturer keeps the specific part in stock at all times. If the part is continuously available, and a reliable procurement time has been established, the practicability of keeping zero stock can be determined. The table will be helpful in determining the cost of keeping parts which are used infrequently.

Here again it may prove to be more desirable to keep an emergency minimum stock, which is replaced by the quick recording of items used on many machines.

14. Establish a minimum stock system for all parts which are to be kept in inventory. The quantity of a part to be kept in stock will be governed by (a) the original decisions that established the need for the part, (b) whether expedited or routine procurement is required, (c) the usage history of the part, (d) the delivery time for the part, (e) the most economical lot size in keeping with procurement cost per individual order and (f) discounts that may apply to quantity orders even though delivery may be scheduled for portions of the total order.

The following minimum stock designation system is suggested as a means of telling the Material Control and Purchasing Departments what procurement conditions apply to each part:

1E. One part is to be purchased by emergency procurement procedures when the one part in stock is withdrawn from stock.

2E. Enough parts to bring stock up to 2 parts are to be purchased by emergency procurements when either one or two parts are withdrawn from stock.

0E. No stock kept on hand but emergency procurement procedures are to be used when an order is placed.

2R. Enough parts are to be purchased by routine procurement methods to bring the stock up to the total amount indicated as the minimum. This minimum is unlikely to apply to items involved in quantity purchase.

0R. The zero minimum is a means of mechanically cross indexing all parts contained in the machines and equipment of a plant. Under this system all machine parts will have an assigned item number which may be coded if desired. This assigned item number is unlikely to be the same as the machine manufacturer's part number. The suffix *E* or *R* indicates the procurement method to be followed if a part is ordered.

4C. A sufficient quantity should be purchased to insure a continuous minimum stock of the indicated quantity. Allowances will need to be made for the requirement procurement time and for usage during the procurement period. Quantity discounts and minimum economical order quantity considerations will also affect order size.

Significant changes in material delivery times will affect the minimum stock required. For example, wartime shortage conditions or a change in status from "manufacturer in stock" to "manufacture upon receipt of order" will require a view of the stock minimum.

When abnormal amounts of material will be required for new equipment installations, the Inventory Control Department should be notified of the impending need as soon as practical so order quantities can be properly scheduled. The Inventory Control records should flag the abnormal quantities required for new construction work so that the correct allowances will be made for normal needs.

The "Insurance" Minimum

In many cases the evaluation of need for a specific part under the previously outlined steps will result in the decision that a certain minimum stock is essential to insure the maximum continuity of production operations. The minimum stock decided upon in these cases can appropriately be called "insurance" minimums. Subsequent usage of some of these parts may raise the minimum stock level for the item, but the master inventory control records should be marked with this insurance minimum to insure that the minimum stock level is not reduced below this insurance level.

15. Periodically review the cost and usage of spare parts for out-of-date models of equipment and machines. Parts for out-of-date models of machines or small equipment items, such as portable power tools and hoists, are usually higher priced than comparable parts for current production models. Delivery time on such parts is longer, and the total inventory investment and yearly usage costs will be higher than for current model parts. In many cases the current equipment model will also clearly provide improved service life between repairs. Thus, a periodic review of total repair and inventory costs for out-of-date equipment and machines will reveal the point where it is economically practical to replace out-of-date equipment.

DISPOSAL OF SURPLUS INVENTORY

All items kept in inventory should be periodically evaluated for the continuing need for the item. It is suggested that the usage history of each inventory item be examined at six months intervals to detect (a) those items which have not been issued for the past year, (b) those items which have not been issued for two or more years and (c) those items whose recent usage has declined to the point where the stock level is too large for the current rate of usage.

On items not issued for two or more years, the existance of the machine containing the item and the continuing need for the item should be verified. On items not issued for one or more years, the current stock level should be compared with the insurance minimum for the item. Stock in excess of the insurance minimum should be evaluated for disposal.

On those items where usage has declined sharply, an explanation for the decline should be determined. If usage is unlikely to increase for a long time, the surplus stock should be evaluated for disposal.

Evaluation for Disposal

Immediate disposal of surplus inventory is not automatically a good business practice. A series of evaluation steps should be performed to determine if reasonable dollar savings can be expected to result from the disposal of the surplus inventory.

A — Determine if the original vendor or original manufacturer will accept the return of the material at a reasonable return charge. Many commercial items such as pipe, pipe fittings, valves and bearings may be returnable to the original vendor who will allow a credit of original cost less a restocking charge. In some cases the original manufacturer will accept the return of items that he is currently manufacturing. Specially manufactured items and parts for noncurrent machine models are rarely returnable for credit.

Occasionally nonreturnable items can be sold commercially by consignment to resale specialists. Salvage and sale of components is sometimes a possibility.

B — Re-evaluate the desirability of surplus disposal when neither a significant per cent of original cost nor a reasonable number of dollars is recoverable. When a surplus inventory item can only be sold for a small part of its original cost or for scrap value, the item should be evaluated as to whether it would be an economic purchase if the price was lowered to the recoverable value plus 52 per cent of the difference between the recoverable value and the original cost. Fifty-two per cent of the difference enters the value calculation because the full inventory loss upon disposal of an item is an operating cost which reduces income before taxes. Thus, 52 per cent of the inventory loss is recovered as an income tax reduction. Surplus items subject to significant deterioration during prolonged storage should not be retained in stock.

If a surplus inventory item can remain in a drawer or on a shelf together with the normal amount of inventory of the same item without requiring additional handling costs, and if the space vacated by disposing of the surplus will not be converted to the profitable storage of other materials, then the actual yearly inventory charge to use in evaluating the desirability of retaining the surplus would be not more than 8 per cent per year per dollar of original cost. This 8 per cent charge would cover taxes, insurance, interest, obsolesence, clerical and supervision charges.

In other words a partially filled storage bin or shelf will have the same space charge as a full bin or shelf. If a fixed crib area is used for storing spare parts, the statistical yearly charge per dollar of inventory will rise during periods of low inventory and will fall with an increasing inventory value. Consideration should be given to the effect of a major dollar volume of surplus inventory being disposed of within any specific period because of the effect upon the profit picture of the company for that period.

Anyone having knowledge that an inventory item is to become obsolete should promptly report the information so that disposal arrangements can be completed at the most advantageous time. The best way to dispose of surplus inventory is to not buy too much in the first place. In other words keep inventory acquisition practices under close control.

MAINTENANCE MATERIALS CRIB OPERATION

An important part of prompt and effective maintenance is adequate availability of the appropriate spare parts and maintenance materials at locations convenient to the Maintenance Departments.

The preceeding discussion was concerned with how to evaluate the need for parts which should be kept in inventory, and the following discussion of maintenance crib operation concerns those items expected to be kept on hand within the manufacturing plant. The small plant will usually operate from a single maintenance materials disbursing crib, but as the plant size increases, the number of cribs will increase to the point that multiple cribs will be supplied from a master crib.

Locate Cribs to Minimize Travel Time

All maintenance material cribs should be conveniently located within the plant area served by the respective maintenance groups in order to minimize the walking or travel time by maintenance men. This time saving also results in lower machine downtime losses. The internal arrangement of the sub-crib should be planned with the thought of reducing travel by the crib attendant. Heavy usage items should be kept near the crib window. Items likely to be used together should be stored close together. Electrical items should be stored in a group separate from pipe items and separate from mechanical items.

Know How Much Is Available and Where It Is

The maintenance material control system should keep its records in such a manner that the exact quantity on hand of each item should be known until the item is issued to the maintenance man. In the case of the master crib-sub-crib system, it will be necessary to keep track of the material in stock in the master crib and in each sub-crib. This multi-crib record keeping increases the clerical operations, but effective maintenance operations can then be supported by a smaller inventory through the redistribution and sharing of available inventory. This also permits a more economical combined volume purchasing of the item for distribution to the various sub-cribs.

Each maintenance sub-crib should contain all spare parts and maintenance materials used in only that plant division serviced by the corresponding maintenance group. Such items should not be stocked in the master crib in order to avoid unnecessary parts delivery delays. Each maintenance sub-crib should also contain in appropriate amounts those spare parts and maintenance materials that have plantwide use, and which may also be stocked in a master crib.

Provide Good Indexes of Available Items

Each maintenance materials crib should be provided with a complete set of indices of all items available from any maintenance materials crib. By thoroughly describing each item at least once in the index listings, cross reference listings under other code words applicable to the item and cross reference listings under the usage classification for the item will make the entire inventory more readily available for multi-application usage.

For example, it is suggested that all items associated with gear reducers should be indexed under "Gear Reducer." If the complete gear reducer is kept in stock, a typical listing could be "348573 Gear Reducer Complete — Model 10RH Ratio 20-1 Right Hand Output Shaft." The separate parts could be typically listed as "348574 Gear Reducer Part — 1151 Output Shaft for Model 10RH Ratio 21-1." All parts kept for the repair of condensate traps could be listed as "656921 Trap — Condensate Return — Part 157 Float for size ¾-in. FT15." This part would also be cross indexed under the key word "Float."

All parts kept for the repair of a specific machine model should be indexed under a common heading. For example, "515303 Lathe Part — 1285 Spindle Gear for Model 12T Serials 125, 185 (X Co. M9100, M9780)." This item would be cross indexed under "Gear." A commercially obtainable bearing for the above lathe would be completely described in the bearings index, and the listing in the lathe parts index would be "152300 Lathe Part — 1287 Spindle Bearing (ND-7200) for Model 12T Serials 125, 157."

Many items are commonly known under several names. Gasket materials may be sheet packing, cork, rubber or asbestos; hence, cross references will be needed under the key words gasket, packing, cork, rubber and asbestos.

Keep a Master Index

A master index should be kept which includes a complete description of the item and a listing of all known machine installations using the item. The machine owners identification number and machine location should also be given. If another stock item can be temporarily used as a substitute, the master index should so indicate. Note that in the typical item descriptions given above, each description begins with an item number such that the item number alone can serve to identify, locate, requisition, purchase, receive and store the item.

Crib Indices

The indices at each crib should be marked with the exact storage location for all items stored in that crib. It is suggested that the master crib index should be marked with the storage locations for all cribs that stock each item. Marking the crib storage locations in the indices permits the maintenance man to write the storage location on the requisition he gives to the crib serviceman, which speeds up crib service and holds down the number of crib servicemen needed.

Marking all crib locations on the master crib index expedites the re-allocation of available stock of all items.

The physical form of the indices can vary to suit the individual company, but the system used should meet the test of (1) being readily updated and (2) being conveniently usable by the personnel who need the indices. It is suggested that the indices be mounted on rotary or swinging carriers along a wall of the crib, in such a manner that the maintenance men can use the indices from one side and the crib servicemen can use them from the other side in order to determine the storage location for incoming items.

It is suggested that the individual item data should be individually removable from the index assembly. Either the individual item strips or the entire index page should be protected by a plastic cover to minimize soiling of the index information. Where automatic machine accounting systems are used for inventory control, the accounting machines can be used to prepare any desired number of duplicate item identification strips for new items or for description revisions to existing items.

For greater accuracy in charging repair parts to the proper machine and to the proper department, it is suggested that area layout maps showing the machine number, machine name and machine model should

be posted near the item indices. These maps often will help the maintenance man find the appropriate group of parts in the indices.

A Typical Storage Location System

It is suggested that the crib storage shelves and bins be marked with a location designation system so arranged that the system will locate an item in a drawer, bin or shelf. This can be done by assigning a section number to each major section of shelves, bins or drawers and to locked cabinets. This major section can be of any length desired. The second step is to assign letters in vertical sequence to each section starting from the floor and proceeding upward with the vertical space assigned to each letter being equal to the minimum height drawer or shelf used in the major section.

If some portion of a major section is equipped with widely spaced shelves only those letters corresponding to the shelf heights will be used. The third location identification step is to number the storage spaces from left to right in each major section. Usually the horizontal storage spaces will be taken as being 4 or 6 in. wide, but other widths can be used as desired.

A similar floor area marking arrangement for locating pallet storage positions could consist of the section number followed by letters to designate the sequential positions starting from the floor for multideck pallet or tote box storage, and followed in turn by the numerical sequence of the pallet starting from one end of the row.

Mark Identity Number on Most Stock Items and on Racks

To the major extent practical, each item in stock should be individually and clearly marked with its identification number. This identification marking on each item reduces errors in handling items within the crib, and it helps to accomplish accurate return-to-stock operations when unused items are returned to the crib.

As a parallel to the marking of the individual item in stock, the bin, shelf or drawer locations should also be marked with labels showing the item number, storage location and at least a partial description. These labels help to keep stock items in their proper location, and they help during re-stocking work.

To assist in the proper identification of newly purchased items, the shipment items should be identified by the use of the vendor's shipping list and by comparison with a copy of the purchase order. Vendors should be encouraged to show the purchase item numbers on the shipping invoice, but this information should be checked against the purchase order copy to avoid clerical errors in descriptions.

Proper Storage Is Essential

All items kept in stock should be adequately protected against moisture damage, corrosion damage, mechanical damage, high temperature damage and low temperature damage. Certain items require dry heated indoor storage, others require only unheated indoor storage, or exterior storage.

Fragile items, such as electronic tubes, require careful handling at all times. Many items as received from the vendor will require additional protection and individual boxing to adequately protect the item against damage during storage.

Provide Prompt and Dependable Crib Service

At the crib service window it is suggested that all maintenance and crib personnel be instructed in the use of a preferential service arrangement whereby any maintenance man needing a part for the emergency repair of critical equipment can ask for and receive immediate service.

An adequate number of crib service personnel should be available in order to minimize the in-line waiting for crib service on the part of maintenance men. If one or more maintenance men are consistently waiting in line to present a material requisition to a crib serviceman, additional crib service personnel are needed.

It is suggested that consideration be given to the use of a self service system of withdrawals from stock and return to stock of maintenance stores. For this system to work reliably, charge-out cards containing the material description should be kept beside or near the individual item. In this way the proper inventory record can be charged or credited as items are removed from or returned to the maintenance stores. This self service system is currently being successfully used to control 35,000 different items in the case of one company which employs 260 maintenance men.

For all items stocked in several cribs, the stock in one crib should not be reduced to zero without redistribution of the remaining stock, unless such redistribution leaves an ineffective quantity in each crib. In this case the material control supervisor should evaluate the situation for the most appropriate replacement method.

In all cases prompt and dependable delivery service should be provided between the master cribs and the sub-cribs and between the various sub-cribs. The lack of prompt service at a crib window or the lack of dependable delivery of items from another crib are both conducive to the hoarding of spare parts by maintenance men.

Salvage and Return Useable Items to Cribs

In maintenance operations it is practical to salvage many items as spare minutes work. The material inventory system should permit the convenient return of these salvaged items to the appropriate storage point. The maintenance management must exercise good judgment in selecting the items on which salvage work is profitable. Salvage work should include the removal and replacement of damaged components in stock items such as electrical controls, valves, etc. For example it may be practical to individually purchase the components required to repair a single stock item.

CONCLUSION

Effective management of maintenance material control and disbursing systems can help a company achieve both lower production costs and improved maintenance operations.

HIGH STRENGTH ALUMINUM CASTING ALLOY M517-T61

A preliminary evaluation

by W. A. Bailey, E. N. Bossing and F. H. Roebuck

ABSTRACT

A preliminary evaluation of M-517-T61 as a high strength aluminum alloy casting material is given. The authors' company is currently procuring structural missile castings of a 356 type aluminum alloy varied by increased magnesium and an addition of beryllium. One of these castings poured in M-517 alloy showed more uniform and higher mechanical properties than those poured in the 356 variant alloy. These results are given with a general discussion of the potential of this experimental alloy.

INTRODUCTION

Several structural missile components are presently cast in a 356 variant aluminum alloy to the chemical and mechanical property requirements of the authors' company Specification D.M.S. 1721. This specification, in addition to describing an alloy composition similar to that of high purity A-356 but with increased magnesium and a beryllium addition, requires ultimate strengths of 50 ksi, yield strengths of 40 ksi and 5 per cent elongation within a one in. gage length in test coupons excised directly from critical areas of the casting.

These mechanical properties are optimistic, and border on the upper limit of the present state of light metal foundry art.

The required strength level of the castings presently purchased to Specification D.M.S. 1721 is verified by the tensile testing of several integrally cast coupon blanks fixed to each individual part of each configuration. The technique was used because of the assumption that the area of the casting directly adjacent to the integral bars is of essentially the same strength level as are the tested bars. This assumption was based upon previous experience with smaller less complicated configurations in which mechanical properties varied but little from area to area.

In larger, more complex castings with considerable variation in section size and in degree of chilling, the assumption is clearly invalid. In unpublished work by W. A. Bailey, marked variations have been observed within extremely short distances, especially in ductility, where 15 per cent elongation directly adjacent to a chill has been seen to progressively fall to 3 per cent ¾-in. from that chill.

Interrelated Metallurgical Problems

Thus, at present, three interrelated metallurgical problems exist for castings produced under the material specification:

1. The problem of consistent foundry conformance with the required mechanical properties.
2. The problem of limited sources for procurement.
3. The problem of lack of correlation between the tensile strengths of the integrally cast test bars and the mechanical properties of coupons excised from the casting matrix.

The simplest theoretical solution to all of these simultaneous problems would be an alloy change, which would permit the pouring of castings to D.M.S. 1721 mechanical properties by foundries of perhaps less technical competence than is now required to properly handle the 356 variant aluminum alloy. In short, ideally, what is needed is a forgiving and more castable aluminum alloy which could meet or better

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the mechanical properties now obtained from coupons excised from the matrix of the high strength light metal alloy castings.

EXPERIMENTAL ALLOY

Previous unpublished work by W. A. Bailey and E. N. Bossing had indicated that the new experimental M-517 copper-silicon-magnesium-aluminum alloy might have some potential in this direction. The limited tensile strength data obtained from castings were promising. Hypothetically, the nominal 9 per cent silicon would give some increase in fluidity, which would in turn permit a lowering of pouring temperature with a resultant decrease in grain size. This lower pouring temperature should, in theory, also reduce the potential level of included hydrogen and perhaps even slightly lessen the hazard of shrinkage and dross. The copper addition might give added strength at both ambient and elevated temperatures. With all these potential advantages a further investigation of M-517 aluminum alloy was definitely indicated.

Toward this direction, a configuration was selected which had been previously produced in 356 variant aluminum alloy, and for which considerable mechanical property data existed which could be used to compare the relative strengths of the two materials. The selected configuration, a 36 in. diameter ring, is diagramed in the figure. Historically, the part had been poured in limited production to D.M.S. 1721 by Foundry B, and is at present cast to the same specification in almost identical shape under a different part number by Foundry A.

The initial pattern equipment was utilized by Foundry B in pouring several pieces of the ring configuration in M-517 aluminum alloy. Pouring, chilling and gating techniques for these castings were said by Foundry B to be identical to their production of the same part in 356 variant aluminum alloy.

The experimental castings were heat treated according to schedule — solution heat treat 12 hr at 980 F, 180 F water quench, artificial age 6 hr at 340 F. One of these castings was submitted to the company's Materials Research and Process Engineering for evaluation. The present paper describes the results of this evaluation.

PROCEDURE AND RESULTS

The casting submitted was clean and acceptable on fluorescent penetrant inspection. Radiographs of the casting showed a quality comparable to that obtained from the production castings of this part poured in 356 variant aluminum alloy by both Foundry B and Foundry A. The overall defect level lay somewhere between Grade B and C of MIL-C-6021D.

A spectrographic chemical analysis of the submitted casting is reported in Table 1. Also appearing in Table 1 is the nominal composition of M-517 aluminum alloy as reported by Foundry B, as well as, the composition limits imposed by Material Specification 1721 for 356 variant aluminum alloy. All production castings of the subject configuration shipped to the company by both Foundry B and Foundry A, of which mechanical property data are herein reported, were within these chemical limits.

TABLE 1 — CHEMICAL COMPOSITION, PER CENT

	Nominal M-517 Aluminum Alloy As Reported	M-517 Aluminum Alloy As Determined	356 Variant Aluminum Alloy Per D.M.S. 1721
Magnesium	0.5	0.61	0.45-0.75
Silicon	9.0	8.9	6.5 -7.5
Iron	—	<0.10	0.20 max.
Manganese	—	<0.07	0.20 max.
Zinc	—	—	0.20 max.
Copper	1.8	1.48	0.20 max.
Titanium	—	0.105	0.20 max.
Beryllium	—	<0.001	0.20 max.
Other Elements, each	—	—	0.05
Other Elements, total	—	—	0.15
Aluminum	Remainder	Remainder	Remainder

The five integrally cast test coupons as well as a number of excised coupon blanks were machined from the submitted M-517-T61 aluminum alloy casting in the locations shown in the figure. These were machined into standard A.S.T.M. Type 2 tensile specimens, and were subsequently tested in tension. A summary of the results of these tensile tests appears in Table 2 for the integral test bars and Table 3 for the excised coupons.

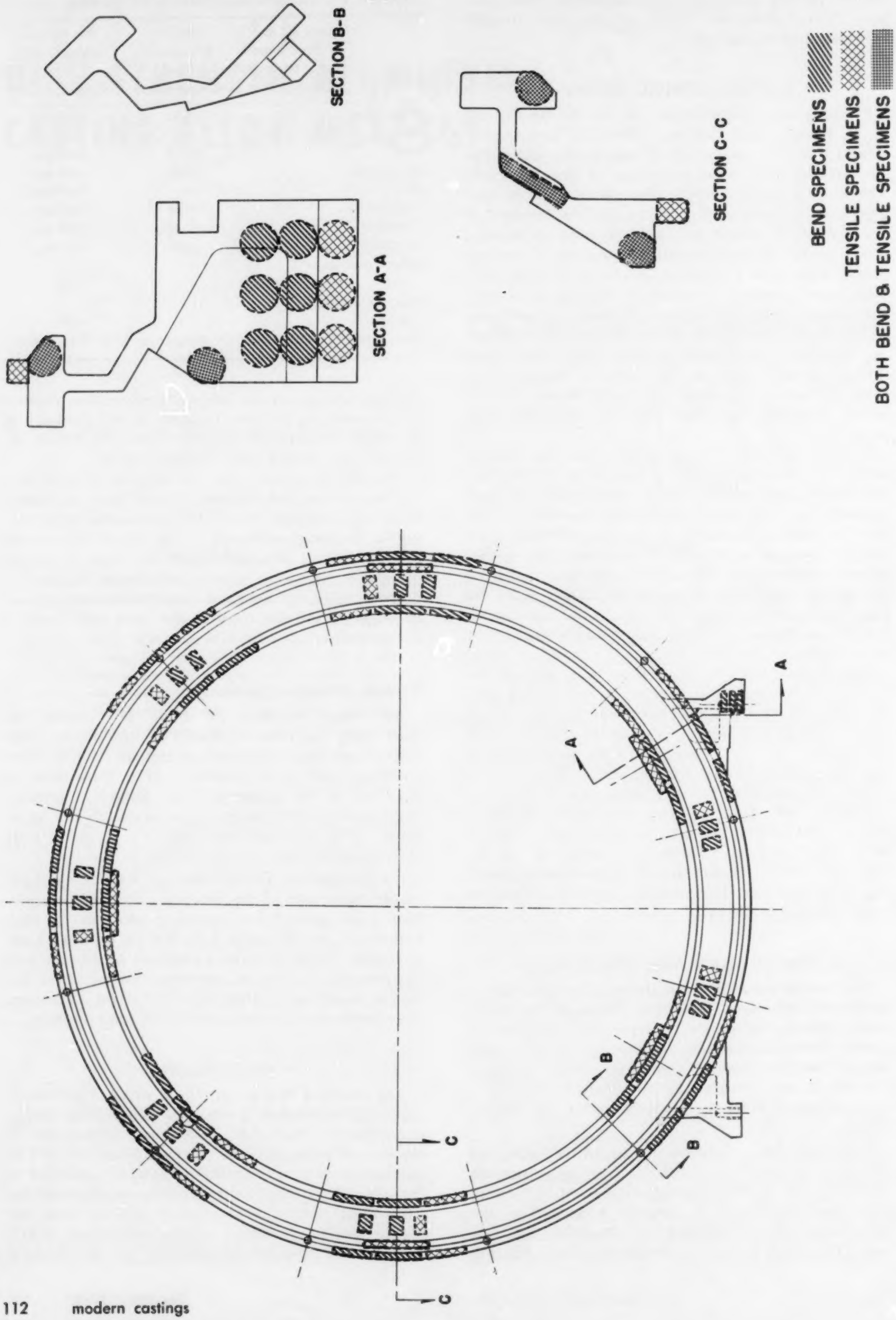
Bending Modulus Specimens

Also machined from the M-517-T61 casting, excised from locations indicated in the figure, were several bending modulus specimens. These were tested in three point loading over a 2 in. span, as described in the paper by J. C. Graddy, "Bending Technique for Evaluation of Cast Materials and Structures." AFS TRANSACTIONS, *vol. 67*, p. 166 (1959). A summary of these results appears in Table 3.

For comparison, Table 2 also lists a summary of the tensile properties of the integrally cast test coupons from parts poured for limited production by both Foundry B and Foundry A in 356-T6 variant aluminum alloy. Table 3 carries a summary of the mechanical property results of coupons excised from the matrix of several of these 356-T6 variant aluminum alloy production castings poured by each foundry.

DISCUSSION

The observed increase in tensile strength and bending modulus, brought about by a simple alloy change is significant, but perhaps of equal importance to the aircraft industry is the fact that in the M-517-T61 aluminum alloy casting, the mechanical properties of the integral test bars are approximately equal to the mechanical properties of coupons excised from the casting proper. In short, within individual M-517-T61 castings, the tensile strengths of the integral


SECTION B-B
SECTION A-A
SECTION C-C
BEND SPECIMENS
TENSILE SPECIMENS
BOTH BEND & TENSILE SPECIMENS
A
A
B
B
C
C

bars may accurately reflect the actual strength of the part which they represent. This, has not been historically true with 356-T6 variant aluminum alloy.

Assuming that the gating, risering and chilling of the M-517-T61 aluminum alloy casting was identical to that used in pouring the 356-T6 variant aluminum alloy production castings and realizing further that the integral test bars on all the castings were chilled, it appears that M-517 aluminum alloy might conceivably be less chill sensitive than is 356 variant. If this reasoning is valid and the limited data reliable, M-517 could potentially have two additional advantages over 356 variant beyond the probable increase in strength level and the possible increase in validity of the integral test bar results.

Metallurgical Requirements

First, the foundry metallurgical requirements might be lessened as the necessity of extreme attention to progressive solidification is reduced. Second, the foundry might more easily meet casting dimensions and tolerances because the placement of a complex chill system sharply increases production difficulties. This should be as attractive to the founder as to the customers because chill blows are always a calculated risk. Also a slightly lower solution heat treat temperature might conceivably reduce the amount of warpage which occurs during water quenching. If the advantages exist, even to a degree, they would be favorably reflected by lower costs in both time and money.

While the M-517 aluminum casting alloy appears to be a most promising material, it must be remembered that any conclusions reached or assumptions made in this report are only tentative and are based on limited data. Much more work must be performed before these observations can be statistically confirmed or rejected. Further, at this moment there is little direct information concerning the foundry behavior of this alloy, its corrosion and stress corrosion characteristics, its heat treat response, fatigue properties and many other factors.

Despite the dearth of such information, M-517 aluminum alloy should be thoroughly investigated. Inherent in the alloy could be, if not a panacea, at least a partial solution to a number of design and procurement problems. It is in this direction that the authors' company is proceeding.

TABLE 2 — MECHANICAL PROPERTIES OF INTEGRALLY CAST TEST BARS FOR M-517-T61 AND 356-T6 VARIANT IN SIMILAR CAST CONFIGURATIONS

	M-517-T61 (Foundry B)	356-T6 Variant (Foundry B)	356-T6 Variant (Foundry A)
Number of Tests	5	60	35
Ultimate Tensile Strength, ksi			
Mode	—	50.5	49.4
Median	55.6	51.0	49.4
Mean	54.7	50.0	49.0
Maximum	58.9	55.5	55.7
Minimum	49.4*	44.6	45.3
Yield Strength, ksi			
Mode	—	40.2	40.1
Median	43.7	41.0	41.1
Mean	44.1	41.2	41.4
Maximum	45.1	45.7	46.0
Minimum	43.2*	37.5	37.2
Elongation, % in one in.			
Mode	—	5.0	3.0
Median	4.5	4.0	5.0
Mean	4.3	4.3	5.2
Maximum	7.5	10.0	10.0
Minimum	1.5*	0.5*	1.0

*inclusion

TABLE 3 — MECHANICAL PROPERTIES OF COUPONS EXCISED FROM THE MATRIX OF M-517-T61 AND 356-T6 VARIANT ALUMINUM ALLOYS IN SIMILAR CAST CONFIGURATIONS

	M-517-T61 (Foundry B)	356-T6 Variant (Foundry-B)	356-T6 Variant (Foundry A)
Number of Tests	22	46	52
Ultimate Tensile Strength, ksi			
Mode	56.3	47.6	48.8
Median	54.6	47.2	49.0
Mean	55.0	46.8	50.1
Maximum	58.9	53.3	54.0
Minimum	48.1	36.4	44.6
Yield Strength, ksi			
Mode	44.0	43.2	43.5
Median	44.0	42.4	42.4
Mean	43.9	42.1	42.2
Maximum	46.9	44.2	46.2
Minimum	41.7	37.1	38.6
Elongation, % in one in.			
Mode	4.5	2.5	2.0
Median	4.5	2.5	2.0
Mean	4.5	2.8	2.6
Maximum	9.5	6.5	6.0
Minimum	1.0*	1.5	1.0
Bending Modulus,			
Number of Tests	44	52	23
Mode	103.0	89.1	—
Median	102.7	84.7	90.0
Mean	101.8	84.9	90.9
Maximum	114.3	100.8	108.6
Minimum	82.6	66.2	78.5

*Inclusion

CONCLUSIONS

As can be seen by comparing the summary of results in Tables 2 and 3, two observations are evident —(1) M-517-T61 aluminum alloy appears to have a marked mechanical property advantage over 356-T6 variant aluminum alloy cast rings and (2) the integral test bars fixed to the M-517-T61 aluminum alloy casting appear to more accurately reflect the strength of the matrix of the casting than do the integral bars of the 356-T6 variant aluminum alloy castings.

ACKNOWLEDGMENT

The authors wish to thank the Aluminum Company of America Research Laboratories for their work in the development of this alloy, and for supplying the test castings used in this research.

ESTABLISHING WORK STANDARDS BY SAMPLING

by E. C. Keachie

ABSTRACT

The author offers an introduction to work sampling giving a comparison of this method with that of various other methods of measuring work. These methods are —stopwatch timestudy, standard data and predetermined work times. The ideas and practices of work sampling are simple and adaptable for obtaining data on the shop floor. It is statistically sound for getting representative samples and for using these samples as a basis for cost control and work improvement.

This introduction to work sampling was presented with an explanatory film as a contribution of the AFS Industrial Engineering and Cost Committee.

WHAT AND WHY

Work sampling is a simple but effective method of determining the time of production operations as a basis for cost reduction, control and general improvement. It is comparatively new, and is increasing in popularity because of its advantages over other work measurement methods. This is especially true where management has relied too much on history and estimate.

In brief, work sampling consists of making random observations of what is done, sometimes with refinements as to the exact nature of the work and performance rating. Observations of several jobs can be made by one observer; the sequence and timing are planned to ensure that the samples taken are truly representative. The total calendar time involved for a single study usually varies from a few days to two weeks.

Results are often startling in revealing the true situation. For example, the total of nonproductive time may be as much as 30 per cent. Corrective action is usually apparent, and the nature of the technique is such as to facilitate making needed changes through employee cooperation.

COMPARISON OF METHODS

A quick look at other means of measuring work will help place each in perspective. To begin with, all management has some idea of what constitutes a fair day's work, if only from habit or vague experience. Next, there are historical records on which both management and labor may rest content, if not efficiently. Often these data are the basis for bids. The data may be highly refined, but may or may not be based on effective methods and standards work.

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Accepted industrial engineering practice includes methods analysis plus stopwatch timestudy, standard data and predetermined work times. These can give precision results, and each had advantages in particular applications.

Stopwatch timestudy is widely used in work measurement. Begun by F. W. Taylor in the late 19th century, it is now a precision tool. Given a thorough methods description, timing by elements and careful setting of allowances, it yields a standard time for operations based on actual work done. Work sampling is also based on actual observation of work done, extended to cover all events during the typical day.

Standard data consists of elemental times for new items that are based on the bank of data already established by stopwatch for similar items. Thus, an operation on a new size of a previously made piece can be timed by reference to standard times on other sizes by interpolation.

Predetermined human work times are operation standard times made up of the sum of ideal component times for each movement involved. Several systems have been developed and are commercially promoted. They have the virtue of requiring a good methods description and close attention as a basis for detailed planning and estimating.

In addition to the direct methods of securing standard times, one should be alert for other indications that may affect the total picture. For example, the manufacturing progress function or so-called learning curve may contribute to improving efficiency over periods of months or longer, with a consequent reduction in manhours per unit produced. This is especially true where designs are complex and subject to fairly rapid change. Numerical or graphical indications of such reduction might indicate the need for new work sampling.

SUMMARY

The ideas and practices of work sampling show simplicity and adaptability of the technique on the shop floor. The process is a simple but sound statistical basis for getting representative samples and using them as a basis for cost control and general improvement.

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Cobo Hall Passes All Exhibitor Tests, AFS-Sponsored Rules Provide Assist

Operating rules and regulations for Cobo Hall, Detroit, pioneeered by the AFS and later adopted by the hall management, contractors and labor leaders withstood the "acid test" during the recent A.S.M. Metals Show held in Cobo Hall.

This show involving 250 exhibits, including displays of heavy machinery weighing up to 57,000 pounds, was attended by Dick Hewitt, AFS Convention and Exhibit Manager, who observed the installation, talked with exhibitors, contractors and hall management. He reported that it went "as smooth as silk."

Further evidence is a front page story which appeared in *The Detroit News* with the headline Cobo Hall Moves To Big Time. This story stated "Cobo Hall passed its big test Saturday and, according to Stephen T. Kish, Civic Center Commission director, has moved into the major leagues as a convention site."

Kish who has had his share of brickbats over past performances at the Hall was beaming Saturday after the manager of the Metal Show heaped praise on the convention facility and what he described as "outstanding cooperation" from the six major labor unions involved in assembling the huge display. He further said that he has never seen "better teamwork" at any Convention Hall.

Kish said, "I think we have made tremendous strides in the last few months. What a lot of people didn't realize at first was that this was a brand new operation for Detroit. Naturally, there were many problems. There always are with anything new. But I think most of the bugs have been shaken out of our operation."

For one thing, Kish said, a set of work rules has been adopted.

As the Metal Show took shape during the week, it was apparent the rules were understood, he observed.

These sentiments were echoed by several exhibitors who were quoted in *The Detroit News* story as saying, "I can honestly say I have no complaints" and another who stated, "I had excellent cooperation."

Sufficient Rooms for 66th Congress

With a record breaking attendance expected for the 66th Casting Congress & Exposition and the 29th International Foundry Congress, AFS has scoured Detroit, Dearborn, and Windsor, Ont., for all available quality hotel rooms.

Almost 5000 hotel and motel rooms have been set aside, 19 hotels in Detroit, five hotels and inns in Detroit and Dearborn, two hotels in Windsor, and 13 motels in Detroit.

A housing bureau has been organized to handle all requests for hotel rooms. Do not contact the hotels directly as they will not accept direct reservations. All reservations will be handled through the housing bureau. Room assignments and confirmations will be made starting Jan. 1. Housing applications will be mailed to the entire industry this month.

Develop Program for International

For the first time since 1952, the United States will be host to the International Foundry Congress sponsored by the International Committee of Foundry Technical Associations. AFS is the sole American member of the Association. The event will be held in Cobo Hall, Detroit, May 7-11, simultaneously with the Castings Congress & Exposition.

Details of the International Congress program were worked out Nov. 6-11 in Zurich, Switzerland, by AFS General Manager Wm. W. Maloney and officials of the International Committee, sponsors of the 1962 "International."

At the Zurich meeting, International President Prof. I. Sans-Darnis of Spain, Vice-President Robert Doat of Belgium, who will preside in Detroit, and Dr. P. W. Mueller, Secretary of the Committee, indicated strong attendance from Europe. Great Britain has already indicated attendance in excess of 100.

Announcements in the three official languages, English, French, and German, have been mailed throughout the world. Other announcements will follow, including one on the study tours, arranged as at all International Congress, to visit important foundry centers.

The newly completed Cobo Hall will be the center of all activities, including registration, exposition, technical meetings, International Committee meetings, luncheons, and International banquet.

The program of technical papers, now well advanced, will be made available to all interested persons. In addition to the scheduled meetings of International Commissions and Working Groups, AFS technical committees will present over 100 papers.

Thirty official exchange papers and international papers will supplement the AFS papers. Those interested in presenting technical papers at this Congress should communicate at once with their member associations of the International Committee or with the Technical Director, American Foundrymen's Society.

Plant Visits

An extensive plant visitation program is well underway now for the 66th Castings Congress & Exposition. Arrangements are being made by the Plant Visitation Committee of the Detroit Chapter Convention Committees. Roger VanDerKar, Hanna Furnace Corp., is chairman and Roy Vorhees, Chrysler Corp., is cochairman.

Other members of the committee are: Robert Bachedorf, General Motors Technical Center; D. R. Bair, Pangborn Corp.; J. H. Barnes, Wheelabrator Corp.; Joseph Barron, Jr., Motor & Machinery Castings Co.; Clair Crawford, Lauhoff Grain Co.; Kenneth Davis, Budd Co.; G. Fellows Ford Motor Co. of Canada, Ltd.; George Frye, Eaton Mfg. Co.; Robert Gardner, Ford Motor Co.; John R. Ikner, Chevrolet-Saginaw Gray Iron Div., GMC; Henry LaForet, Pontiac Motor Car Div., GMC; Vernon J. Sadler, General Foundry & Mfg. Co.; Stanley Strand, Cadillac Motor Car Div., GMC; Anthony Waller, Swedish Crucible Steel Co.; Michael Warchol, Atlas Foundry Co.; and Grant Whitehead, Dace Industries, Ltd.

METALCASTING NEWS

Highlights at Regionals

Reports on Societies

Form New AFS Committee

Economist Predicts Steady Expansion At Equipment Manufacturers Meeting

Business in general will continue its steady advance, Foundry Equipment Manufacturers Association members were informed at the annual meeting held at the Greenbrier, White Sulphur Springs, W. Va.

This feeling found general agreement. However, some felt that the outlook was not quite as favorable for the foundry industry which is lagging behind the increases of other industries.

Substantiating evidence for the improving business conditions were given by Douglas Greenwald, manager of Economic Services Dept. of Economics, McGraw-Hill Publishing Co. Among the indications cited by Greenwald for business improvements were:

A predicted 10 per cent increase in new machinery for the coming year.

The urgent need for U. S. industry to modernize and replace obsolete facilities.

Currently low business inventories in relation to current shipments and new orders.

A sharp increase in pre-tax profits.

The consensus at the meeting validates the Modern Castings survey in the November issue. The trends panel, consisting of metalcasters and suppliers, predicted a business pick-up in the first six months of 1962. Some 89 per cent of the foundrymen and 91 per cent of the suppliers anticipated increases in the first half of the year.

Possible controls on business in connection with Washington's industrial mobilization plan were explained by Richard R. Salzmann, director of public services, Research Institute of America. Salzmann advised a review of inventory policies, relaxation of recession controls on inventory, and to re-evaluate purchasing philosophies.

AFS Convention and Exhibit Manager Richard J. Hewitt spoke on the 1962 Detroit International Congress & Exposition. F.E.M.A. Director C. H. Barnett discussed the rate of activity in the foundry equipment industry, and F.E.M.A. President E. A. Borch presided and presented the annual report.

F.E.M.A. Names Brackett

Richard A. Brackett, Spencer Turbine Co., has been elected president of Foundry Equipment Manufacturers Association. Other officers are: 1st vice-president, Chester G. Hawley, Jeffrey Mfg. Co.; 2nd vice-president, Ralph M. Trent, Pangborn Corp.; and executive secretary-treasurer, C. R. Heller. Three directors were elected: David G. Gallaher, Clearfied Machine Co.; George O. Pfaff, Wheelabrator Corp.; and Gordon E. Seavoy, Whiting Corp.

Plan Two Foundry Tours For Overseas Guests

AFS has arranged for two tours for international visitors to the 29th International Foundry Congress to be held in Detroit, Mich., May 7-11, 1962. Cooperating with the tours are the U. S. Agency for International Development (A.I.A.), successor to the International Cooperation Administration (I.C.A.) and member associations of the International Committee of Foundry Technical Associations.

Both tours start in New York on April 24, remain in Detroit from May 6 to May 11, then follow identical itineraries ending in New York on May 12.

Tour "Blue" includes visits to Cleveland, Chicago and Milwaukee. Tour "Yellow" will visit Philadelphia, Birmingham, Ala., and Indianapolis, Ind. After the Congress, visitors may travel independently or return direct to New York on Tour "Green."

Data on foundries scheduled for plant visits by the study teams will be made available to persons expressing interest and in the final tour itineraries.

Overseas visitors who plan to attend the International Congress on an independent basis may participate in phases of the tour. However, AFS must be notified in advance so that local transportation can be arranged.

Applications can be made to AFS General Manager Wm. W. Maloney, AFS Central Office, Des Plaines, Ill., or with any office of Thomas Cook & Son.

In addition to these booking methods, certain financial assistance may be available to persons who qualify under the rules of the U. S. Agency for International Development or the Dept. of State. Persons interested should apply promptly to offices or missions of A.I.D. or to U. S. Embassies or Consulates overseas. AFS cannot accept responsibility for obtaining such assistance.

Superior, Fulton Halt Foundry Operations

Operations at Superior Foundry, Inc., Cleveland, halted Nov. 10 after 71 years. The foundry was one of the largest and oldest in the greater Cleveland area.

In 1958, Superior Foundry acquired Allyne-Ryan Foundry Co., Cleveland, and consolidated its operations into Superior Foundry. The old Allyne-Ryan properties were sold recently.

Superior President Walter L. Seelbach stated that the company was not in financial difficulties but that the stockholders voted to close due to "the profit squeeze" under which "excessive Federal taxes leave insufficient funds for reinvestment in the business." Seelbach also cited "the high cost of Ohio Workmen's Compensation and the recent trend in the greater increase to workers under that law, the greater

increase in wages than in production and President Kennedy's request to manufacturers to hold the price line in face of rising wage costs."

Fulton Foundry & Machine Co., Cleveland, discontinued operations earlier in November.

U. S. Pipe & Foundry Co. Completes Two Purchases

U. S. Pipe & Foundry Co., Birmingham, Ala., has acquired the Chattanooga, Tenn., soil pipe division of Combustion Engineering, Inc., for an undisclosed amount. The operation will continue as a division without change in personnel. The purchase marks entry in the soil pipe field for U. S. Pipe which manufactures pressure pipe for transmitting water and gas.

U. S. Pipe has also acquired the business of T. C. King Pipe and Foundry, Anniston, Ala., also a manufacturer of soil pipe and fittings. It will be operated as part of the Soil Pipe Div.

Central Foundry Wins Projectile Contract

Central Foundry Div., General Motors Corp., has been awarded a research and development contract for production engineering of a new type 105 mm projectile. The main body will be pearlitic malleable.

Issued by the Army Ordnance Corps, Detroit Ordnance District, the contract calls for a five-phase engineering program to make possible the mass production of the projectile.

Inductotherm Corp. Moves

Inductotherm Corp., manufacturer of high frequency induction melting and heating equipment, has moved to a new plant at Rancocas, N. J. The building has 35,000 sq. ft. of floor space and twice the size of the former plant.

A. E. Olson Forms Firm

Northeast Refractories Co., Old Saybrook. Conn., has been formed by Arthur E. Olson, manager. The will represent several manufacturers of clay graphite refractories and specialty clay products.

Gray Iron Founders Stress Importance of Research

Emphasis on research was provided by speakers at the 33rd annual meeting of the Gray Iron Founders' Society held at Toronto, Ontario, Canada.

Henton Morrogh, director of the British Cast Iron Research Association, Birmingham, England, spoke on current British gray iron research activities.

A radical proposal for foundry research was proposed by Allen M. Slichter, Pelton Steel Castings Co., Milwaukee.

Addressing gray iron foundrymen and speaking for the Steel Founders' Society, Slichter recommended that the American Foundrymen's Society offer its services to the industry to supervise an industry-wide program of basic research. The proposed plan would be financed by contributions from various trade associations based on a percentage of sales volume.

Slichter advocated grants in aid for fundamental research from the trade associations with supervision by an AFS-appointed committee consisting of association technical directors. The AFS technical director would act as chairman. Basic research, he said, would prevent or overcome industry losses.

Slichter pointed to the success of the Steel Founders' research program and its application by members.

R. W. Hale and H. W. Lownie, Battelle Memorial Institute, Columbus, Ohio, presented a progress report on a technical-economic survey of customer industries being made for the society.

Other speakers were: Hoyt P. Steele, Government Relations Service, General Electric Co.; C. C. Williams, Jones, Day, Cockley & Reavis, Cleveland; J. Lewis Powell, Washington, D. C. Three new G.I.F.S. educational films were shown. G.I.F.S. President John E. McIntyre, Sibley Machine & Foundry Corp., South Bend, Ind., presided.

R. M. Gold, Dayton Rogers Co., Minneapolis, has won first prize in the G.I.F.S. design contest. His design was substitution of gray iron for a fabricated steel knife slide on a shell trimmer. Second prize was shared by L. F. Fougere and W. B. Moyer of General Electric Co., Schenectady, N. Y. Six, third prize winners were: P. J. Binker and C. W. Mathues, National Airoil Burner Co., Philadelphia; A. S. Melilli, General Electric Co., Everett, Mass.; E. B. Melton, Dominion Engineering Co., Ltd., Montreal, Que.; C. L. Peterson, Uarco, Inc., Chicago and L. C. Noriega, General Telephone & Electronics Corp., Salem, Mass.

Non-Ferrous Founders Name Mitchell President

Dan A. Mitchell, Progressive Brass Mfg. Co., Tulsa, Okla., has been elected president of the Non-Ferrous Founders' Society, Evanston, Ill. Other officers: 1st vice-president, L. J. Andres, Lawran Foundry, Milwaukee; and 2nd vice-president, George W. Stewart, East Bay Brass Foundry, Richmond, Calif. Herbert F. Scobie, executive secretary, continues as secretary-treasurer.

Members of the executive committee for 1961-62 are Mitchell, Andres, Stewart, immediate past president Elmer G. Brummund, Jr.,

Brummund Foundry, Chicago; R. E. Dickison, Brass Foundry Co., Peoria, Ill.; N. W. Meloon, Meloon Bronze Foundry. Syracuse, N. Y.; all re-elected, plus Walter O. Larson, Grafton Foundry, Grafton, Ohio.

New national directors are: Jack Bodine, Bodine Pattern & Foundry Co., St. Louis; Gunnard Eliason, Alloy Bronze Casting Co., Pittsburgh, Pa.; and Charles H. Stokesbury, Derby Castings Co., Seymour, Conn. Re-elected directors in addition to Mitchell are: William Grimm, William Grimm Foundry, Philadelphia; Leon Morel, Jr., Morel Foundry Corp., Seattle, Wash.; and John C. Emery, Racine Foundry & Mfg. Co., Detroit. William A. Gluntz, Sr., Gluntz Brass & Aluminum Foundry, Cleveland, was re-elected to a three-year term as a director at large.

Interim appointments by President Mitchell returned the following former national directors to one-year directorships; P. E. Lankford, East Birmingham Bronze Foundry, Inc., Birmingham, Ala.; C. J. Egetter, Crown Brass Mfg. Co., Alhambra, Calif.; and Raymond E. Bietry, B & S Foundry, Inc., Brooklyn, N. Y.

Walter M. Clark, D. W. Clark & Co., East Bridgewater, Mass., was given the Society's distinguished service award.

National officers of the Cast Bronze Bearing Institute, a product group of the Non-Ferrous Founders' Society, were re-elected for a 1961-62 term.

Malleable Founders Study New Market Possibilities

Investigation of new and growing markets were studied at the Malleable Founders' Society 12th annual market development conference held in Cleveland.

Emphasis was placed on the $95 billion government market. Speakers included John V. Segarese, Picatinny Arsenal; Colonel Ralph M. McMahon. Cleveland Ordnance District; and H. Mansel Evans, Pentagon specialist in small business.

The weldability and machinability of malleable iron were discussed in seminars. Possibilities in state and municipal governments were also discussed. Guest speakers were Roy L. Greenman, Michigan State Highway Dept. and John Tewart, Westinghouse Lighting Div., Cleveland.

Warn Industry Must Be Alert to New— Re-Examine Fundamentals to Survive

Speakers at Purdue call for critical appraisal of manufacturing, marketing and quality control programs. Heavy competition forcing foundries to take offensive in battle for markets.

Howard B. Vorhees, Purdue Metals Casting Conference Chairman, opens the 14th annual conference held at Purdue University.

New technology shared the spotlight with calls for a critical re-examination of metalcasting fundamentals and philosophies at the Purdue Metals Casting Conference. The two-day meeting was held Oct. 26-27 at Purdue University, Lafayette, Ind.

Business conditions in the Indiana, Illinois, Michigan area were reported spotty both for locations and for metals. In general, business appears to be up roughly 10 per cent from a year ago.

Despite this increase, the basic conference question was, "Why isn't the industry selling more castings?"

Several speakers traced it back to industry philosophies. T. E. Barlow, Eastern Clay Products Div., International Minerals & Chemical Corp., Skokie, Ill., pointed out that foundrymen have had it too easy in the past. He emphasized that it is too easy to get a sand mixture, too easy to obtain metal from the cupola, too easy to obtain a casting. He pointed out that at one time there was no competition for metal shapes and no merchandising program required. Other forms of competition had to start from scratch and had to sell against castings, forcing a quality control and merchandising program, he stated. He said that it was essential to view quality control as a selling tool rather than a cost. "The question facing us is whether good enough is really good enough," he stressed.

A re-evaluation of research and sales policies was advocated by B. L. Simpson, National Engineering Co., Chicago. Considerable money and effort has gone into both of these areas, he stated, but a far more effective job could be done through centralization. The basic problem has been the diffusion of efforts by companies and trade groups within narrow bands. A bright future was predicted by "this basic industry in transition." He warned that foundrymen themselves hold the key to the industry's future.

Observations in Europe by L. J. Pedicini, Lester B. Knight & Associates, Chicago, were that American foundrymen can not expect new process to solve their problems. In answer to what American foundrymen can expect from Europe, Pedicini listed two factors. First, basic research in sand control and formulations. Second, refinements in automation originated in this country. He warned that this country has no advantage in machine components and that with emphasis on research and fundamentals that increasing European competition will come.

New technology calling for strict controls were discussed by David Matter, Ohio Ferro-Alloys Corp., Canton, Ohio, and Wayne Buell, Aristo Corp., Detroit. Ductile iron production will continue to rise, said Matter, with advances led by applications in the fluid handling field and the automotive industry. He said that within five years ductile iron production would increase from 1¼ of the industry's total to 5 per cent.

Buell spoke on use of furan binders, both the hot box and the cold curing process. He pointed out that the trend in coremaking is toward processes permitting bonded sand to be cured before removal from the core box. Advantages of the furan binders include improved core dimensions, elimination of contoured drying plates and curing ovens, decreased labor and manufacturing costs.

A re-evaluation of present processes can also lead to an industry-wide movement to regain and increase metalcasting markets, stressed several of the speakers.

C. A. Sanders, American Colloid Co., Skokie, Ill., predicted more salable, more competitive castings through better trained technicians and improved sand control. These practices include checking of supplies, proper ramming, mulling, and additions, and constant control. He observed that, "Many foundrymen are too busy making fair castings that they haven't time to make them better."

D. L. LaVelle, American Smelting & Refining Co., South Plainfield, N. J., in discussing non-ferrous melting methods said that management must keep up with the latest developments. He outlined the features of electric, crucible, and reverberatory furnaces. These, he said, must be plotted against money available, amount of metal, melt size, number of alloys, pouring temperature, casting size, metallurgical considerations, casting quality, and fume control considerations.

W. M. Ball, Jr., R. Lavin & Sons, Chicago, outlined how many non-ferrous problems could be solved through a simple matching system. He recommended two classifications. One consisting of eight metal categories and the other of common problems.

Substantial savings in cleaning room costs are possible through the use of an electric arc-compressed air process, pointed out Dale Hall, Oklahoma Steel Castings Co., Tulsa, Okla. He stated savings increase with casting size but that cost reductions can be made on all.

Core economies were discussed by R. J. Bossong and J. R. Jenkins, American Steel Foundries, Alliance, Ohio. They stated that new production methods in the core department had lowered core room man hours 20 to 30 per cent in the last 10 years through the use of batch, tower, and dielectric core ovens.

Other speakers were AFS General Manager Wm. W. Maloney, AFS Regional Vice-President T. T. Lloyd, AFS National Director Carl Schopp.

Howard B. Vorhees was the conference chairman. James C. Maggart was program chairman, and J. B. Essex was assistant program chairman.

New England Metalcasters Told to Squeeze Costs with Better Controls

Much of the new technology provides tools for bringing every metalcasting operation under closer control. Conference speakers discuss most important of these.

New England metalcasters are finding it difficult to convince customers that the added costs of new technology may increase the selling price of castings but that ultimate cost of the finished product is materially reduced.

This problem was basic to many of the discussions both in the technical sessions and the corridor-comments at the 21st New England Regional Foundry Conference at M.I.T., October 13 and 14.

The sooner that casting producers can get customers to look at the end value instead of the cost per pound of delivered metal, the better their chances of becoming a profitable operation.

Cutting costs and at the same time improving quality is the tough assignment facing the metalcasting industry today. One way to do this is with an efficient material handling system. In the words of Roy Hayward, Draper Corp., such a system "is an investment; an opportunity for savings; a means of staying competitive; a way to increase worker's morale and safety; and allows for closer cost control."

Cost control in the cleaning room of Link Belt Olney Foundry was documented in a set of sample record sheets distributed by their superintendent Charles W. Mooney, Jr. Foundrymen in attendance were impressed by the extensive records kept and the results achieved.

In discussing core cost control Gerrit H. Ebbeling, Whitin Machine Works, stated that he operated on the premise that "the best core is the cheapest one that does the job."

Apply Quality Control

"Quality control enables us to supply the right information to the right man at the right time to prevent all avoidable defective castings," said Clive J. Wilson, Joy Manufacturing Co., in a talk which detailed three areas of quality control:

1. Before castings and patterns are ordered;
2. In all foundry operations with aid of statistical methods; and
3. Contact with customers after receipt of castings.

In spite of added cost per pound ductile iron has established a sizeable franchise in the metalcasting market. Today there are some 225 producers of ductile iron. David Matter, Ohio Ferro-Alloys Corp., revealed in his talk that approximately 20 per cent of the ductile tonnage was being made in acid cupolas, 70 per cent in basic cupolas, and balance in arc, induction and air furnaces.

The water-cooled cupola received a complete going-over by Arthur C. Buesing, Brown Metals, Inc. The speaker traced the history of this development and described the very newest refinements.

Help for Casting Bronzes

Brass and bronze foundrymen were encouraged to learn from C. W. Ward, Jr., American Radiator & Standard Sanitary Corp., that "their kiss-gating technique has simplified gating, reduced pattern costs, minimized misruns, improved surface finish, eliminated cut-off and grinding costs, expedited cleaning room traffic, and eliminated machining."

Since many customers demand pressure tight castings from copper-base casters, the subject came up for extensive discussion by Robert Rosenberg, Mitron Research & Development Corp., William Schmidt, Foundry Consultant, and Bernard Ames, Columbian Bronze Co. Tin bronzes have to be poured as cold as possible to be pressure tight. But Ames advised turning to high strength, short freezing range, high shrinkage aluminum bronzes for pressure tight applications. Just be sure to have adequate risers and a gating system that catches dross.

Rosenberg achieves pressure tightness by establishing a temperature gradient in the casting of at least 60 F per inch when pouring the difficult long freezing range alloys.

The ultimate solution, as Ames put it, is to educate the purchasing agent to accept one of the aluminum bronzes which are initially more expensive but eventually result in lower end cost.

Casting pressure tight aluminum received a complete treatment by Professor Merton Flemings, M.I.T. Alloys containing silicon are best suited where pressure tightness is required. Foundrymen should establish thermal gradients by chilling the casting and insulating the risers.

Raymon Meader, Whitin Machine Works, presented each man in the audience with a simplified but scientific guide to gating of gray iron castings. The graphs and tables prepared for this practical guide permit calculation of gating systems for any gray iron casting of any analysis, poured at 2600 F minimum.

Young Men Needed

In searching for new technology and making better products the metalcasting industry must not overlook the importance of bringing young men into the industry. This responsibility was pointed up by Foundry Education Foundation President David H. Morgan who emphasized: "To attract young people, we must know their expectations and must make them realize that the foundry industry provides opportunities."

"Our industry, the importance of our products, and the challenges and rewards are unknown to most potential employees. The problem is communication, which requires personal time, effort, and money from foundrymen, companies, and industry organizations."

Charles T. Sheehan, Executive Secretary of the National Foundry Association, warned metalcasters of the many plans underfoot by unions to resist mechanization and automation in their plants. Modernization has been virtually stopped in some instances by union pressures!

The Conference Co-Chairmen were Phillip C. Smith, General Electric Co. and Lewis W. Greenslade, Brown & Sharpe Mfg. Co. They were assisted by Ferrous Co-Chairmen William Sommer, Plainville Casting Co., and Dale Waterhouse, Grinnel Corp., and Non-Ferrous Co-Chairmen E. Frank Tibbetts, Wollaston Brass & Aluminum Foundry, and Robert Ashley, American Radiator & Standard Sanitary Corp.

Michigan Foundrymen Aim at Meeting Customer Tolerance Requirements

Regional Conference focuses attention on ways to meet ever increasing demands for closer tolerances in dimensions, metallurgy, and physical properties.

The Michigan Regional Foundry Conference at Michigan State University, October 19-20, was strongly oriented to the diverse interests and needs of metalcasters serving the automotive industry. The program was shared with over 90 college engineering students and their professors brought from Michigan educational institutions at the expense of Conference sponsors.

A special session "Challenge of the Foundry Industry to the College Student" was aimed at acquainting them with the career possibilities in the industry. Student comments indicated that the foundry industry was not doing as good a job at recruiting as competitive industries. Although the door is open to them, it is too often left to the student to beat the path to this door.

Special recognition was given the student-educator group by T. T. Lloyd, Albion Malleable Iron Co., in a luncheon talk.

Nine Round-Tables

Nine simultaneous round table discussions proved to be one of the most successful events on the program. By breaking up into small groups, foundrymen were able to exchange experiences and find answers to individual problems in the following specialized areas: 1. Ductile Iron; 2. Malleable Iron; 3. Cupola Operation; 4. Shell Molding; 5. Dies, Molds, Patterns; 6. Ferrous Castings; 7. Foundry Sands; 8. Non-ferrous Castings; and 9. Plant Engineering and Maintenance.

Probably no group of metalcasters is receiving more pressure to meet stringent tolerances than those serving the automotive industry.

A cross section of opinion on future trends in casting tolerances was presented by a panel in which Robert W. Gardner of Ford Motor Co. covered metal composition; T. R. Schroeder of General Motors Corp. discussed molding techniques; Frederick J. Hodgson, Eaton Manufacturing Co., handled core making; Victor A. Pyle, Pyle Pattern & Mfg. Co., represented pattern equipment; and C. William Yaw, General Motors Corp., defended machining shop requirements.

With automatic molding of thin-walled iron engine blocks competing with light metal die castings, close tolerances in every operation are an absolute must. You must start with accurately machined patterns; mold wall movement cannot be tolerated; cores must be made with the new high-accuracy processes; elaborate core set fixtures are essential; and metallurgical controls on gray iron need improvement.

Yaw pointed out that its the "hardness variations from casting to casting that hurts the machine shop efficiency."

One of the answers to tolerance demands lies in furan resin binders. In experiments described by J. P. Cummings, International Harvester Co., molten iron at 2700 F was poured over flat cores bonded with furan, oil, and phenolics. Less deformation occurred in the furan than the other two, leading Cummings to conclude that "we can expect to hold closer casting tolerances with furan than possible with previously used materials."

As pointed out earlier in the Conference, casting tolerances are limited by the tolerance of variations of each ingredient in the foundry processes. Molding sand has been particularly a bad actor because of the many variables contributing to its final performance in contact with molten metal. A new moldability test promises to aid this cause considerably.

T. H. Hanna, Harry W. Dietert Co., described the moldability controller and A. F. Tankovich described his experiences with it at Midwest Foundry Co.

New Pattern Materials

"Epoxy resin pattern equipment can be produced at an average cost of 50 per cent below metal patterns—and a duplicate pattern reproduced at about 80 per cent below metal cost." These praises come from Robert J. Simon, Central Foundry Division, GMC, as the result of his experiences with epoxies at Saginaw.

William Weaver, Modern Pattern and Plastics, Inc., broadened the outlook with his comments on the use of such new materials as silicon rubber and polyethylene for patterns.

An audience comprised largely of gray iron foundrymen listened intently to Harry McMurry describe the tough competition they are up against at Ford's "hot metal" die casting and permanent mold foundry in Sheffield, Ala. Because of closer casting tolerances, faster machining, longer tool life, lower shipping costs, and lighter weight, the final cost of die cast aluminum parts makes rough competition for gray iron.

Tour Olds Plant

By approaching the problems of gating molten metal from the viewpoint of fluid mechanics, Professor Jack Wallace, Case Institute of Technology, explained to metalcasters how his system can be made to work for all metals in all situations.

New market opportunities for metalcastings in the automotive, farm machinery, railroad, machine tool, and aerospace industries were detailed by Jack H. Schaum, Editor of MODERN CASTINGS. Schaum exhorted foundrymen to do more research on improving their own practices as well as helping each customer improve his products.

Since 1956, the Michigan workmen's compensation insurance rates have risen 42 per cent and the loss ratios are the highest in the nation, according to F. S. Warner, Auto-Owners Insurance Co. In his report at the Michigan Conference, Warner warned foundrymen that if this trend continues the cost of the program will become intolerable.

The Conference closed fittingly with a tour of the Oldsmobile plant of General Motors in Lansing. Organization of the Conference was in the hands of General Chairman Jerome R. Young, Cadillac Motor Car Div., GMC, and Vice Chairman Donald E. Dice, Albion Malleable Iron Co.

Griffin Wheel Completes $6 Million Foundry

Griffin Wheel Co., a subsidiary of American Steel Foundries, Chicago, has completed construction of a $6 million plant in Bensenville, Ill., to produce steel wheels for railroad freight cars. It is Griffin's sixth steel wheel plant and the fourth to be completed by the company in less than five years.

The plant can turn out 148,000 steel wheels annually, bringing Griffin's total capacity to about 525,000 yearly. Wheels are formed with the company's patented controlled pressure process of direct casting. Air pressure is used to force molten metal up from an airtight chamber into a graphite mold. Griffin has turned out more than 1,750,000 wheels since it opened its first controlled pressure pouring plant at Chicago in 1952.

AFS Committee Initiates Study of Water Pollution

Preliminary steps have been taken in the investigation of foundries and water pollution. The study is being conducted by the AFS Water Pollution Committee.

At its initial meeting the group outlined purposes and made committee assignments. Object of the committee's work is to:

Explore the problem of water pollution from foundry wastes.

Determine whether or not a problem exists.

If a problem exists, determine whether it is major or minor.

Find out the maximal allowable concentration of contaminants.

Report standard methods of testing and sampling in order to determine the degree of water pollution.

Recommend means of selecting and handling materials to minimize water pollution.

Recommend treatment methods for contamination control and/or destruction.

Stress New Applications At Ductile Iron Meeting

Operating problems, new uses for ductile iron, and activities of the Ductile Iron Society were featured at a recent general meeting held in conjunction with the American Society of Mechanical Engineers.

Four technical papers were presented: "Some Engineering Applications of Ductile Iron Castings," S. F. Carter and J. J. Dow, American Cast Iron Pipe Co.; "Uses of Ductile Iron in Paper Mill Machinery," F. C. Hardick, Sandy Hill Iron & Brass Works; "Yttrium—Nodular Iron," J. J. Kanter, J. P. Magox, and W. L. Meinhart, Crane Industrial Products; "Applications of Ductile Iron in Special Machinery and Electrical Power Fields," R. J. McGiveny, Crompton & Knowles Co. D.I.S. Executive Secretary J. H. Lansing, acted as chairman of the A.S.M.E. ductile iron session.

Sibley Foundry Installs New Induction Receiver

Higher quality gray iron is opening new markets for Sibley Machine & Foundry Corporation, South Bend, Ind. The firm has installed the first low-frequency induction forehearth of its kind in a U. S. foundry.

Every 20 minutes a ton of molten cupola iron is transferred to the 8800 pound capacity induction holding unit where it is super heated, refined, and alloyed (if necessary).

In justifying the expenditure of some $50,000 with this modernization, Sibley Foundry president John E. McIntyre comments: "Pressures from customers and competitive materials are forcing foundries to improve their operations with the latest technology." Already Sibley is working on a big order from Bendix Aviation Corp. for automotive hydraulic valve bodies. The superior tensile strength and tight grain combined with exceptional machinability of the induction treated iron has led Bendix to specify it for this application.

Since each batch of metal in the furnace can be treated individually, Sibley has a new flexibility that permits their metal to be customized to meet each customers needs. Alloy losses are virtually nil because of the controlled horizontal stirring action of the low-frequency current. Steel scrap is easily added to the molten iron in the receiver to lower carbon content.

American Steel Foundries Considers Name Change

A change of corporate name from American Steel Foundries to Amsted Industries, Inc., will be up for consideration at the annual meeting in January. Diversification of activities and income has prompted the proposed change. Only nine of the company's 24 plants are steel foundries. During the past 12 years corporate income from steel foundry operations has declined from 92 to 50 per cent.

To preserve the substantial commercial value of the American Foundries name, established over a period of 60 years, the Transportation Equipment Div. and the Hammond Div. will be operated as American Steel Foundries, Inc.

G. E. Smith Signs Agreement

G. E. Smith, Inc., Philadelphia, Pa., maker of binders and other chemicals for the foundry industry, has signed a third licensee agreement in a foreign country. Silicatos Solubles De Mexico, S. A., will manufacture the no bake binder, hot box binder, and washes. Silicatos Solubles will sell in Mexico.

AFS CHAPTER NEWS

NORTHWESTERN PENNSYLVANIA—How management evaluates AFS was discussed by AFS General Manager Wm. W. Maloney. Seated are Maloney and National Director Wm. Oliver. Standing: K. T. Guyer, former National Director, R. Griswold, C. H. Bendig, and former National Director L. D. Wright—by Walter Napp

CENTRAL OHIO—Speaker Clyde Sanders, American Colloid Co., center, spoke on good and bad sand practice. Others are: Chapter Chairman N. V. Stapf; M. Moore; Technical Chairman J. E. Haller; and Secretary R. E. Moone—by Russell Marande

ONTARIO—R. L. Hart, center, Canada Wire & Cable Co. Ltd., stressed how good supervision pays dividends. Others are Chairman R. S. M. Gray and Technical Chairman George Turnbull.—by S. J. Frizzel

TENNESSEE — Shown at recent outing are Vice-Chairman A. B. Helms, 2d from left, and Chairman J. L. Payne, right. Birmingham guests are Chairman A. M. Garrison and Secretary R. A. Peterson—by Tom Pelham

Northeastern Ohio Chapter

Modern Sand Practices

Modern sand composition, mixing, and ramming processes was explained at a recent meeting by Prof. R. W. Heine, University of Wisconsin. AFS Secretary A. B. Sinnett described plans for the 1962 Castings Congress & Exposition to be held in conjunction with the 29th International Foundry Congress.

Molding sand, especially silica sand, expands when it is heated, resulting in such mold defects as buckling and veining, said Heine. He said these defects can be eliminated by maintaining clay content at proper levels since bentonite shrinks when heated, counteracting the expansion of silica sand. Heine also stated that clay content should be evaluated by measuring effective clay content—the amount of new clay that equals the green compressive strength and green shear strength of the clay in the sand being tested. By maintenance of effective clay content at proper levels, the sand will have consistent molding properties, he observed.—by Wallace Huskonen

Piedmont Chapter

Sand Control of Moldability

Explanation of a moldability controller was given by Tom Hanna, Harry W. Dietert Co., Detroit. The instrument adjusts water additions to the sand automatically to maintain a pre-determined physical property rather than a constant moisture level. The sand is controlled to constant moldability, water being only one component. Molds are reported to have more uniform properties and less subject to drawing problems.

Prior to the evening session, a visit was made to the Wayne Agriculture Works foundry to see a demonstration of a fused silica product. It is useful for producing semi-permanent molds, shell back-up forms, and various refractory products.—by Larson E. Wile

Central New York Chapter

Pricing for Profits

The mechanics of pricing for profits were outlined by Roger B. Sinclair at a recent meeting. He discussed the fundamentals in a step-by-step development of costs on typical castings.—by Anthony F. Izzo

ONTARIO — Use of the carbon injection process was explained by J. E. Wilson, center. Others are Technical Chairman N. H. Couke and Chapter Chairman R. S. M. Gray —by S. J. Frizzell

ONTARIO — Chapter Chairman R. S. M. Gray and two winners in the Chapter's technical paper contest, R. D. Scott and C. J. Macfayden. Not shown is L. E. Boorman, also of Canadian General Electric Co. and R. H. Forscher, Aluminum Co. of Canada Ltd.—by S. J. Frizzell

EASTERN CANADA—Recent technical sessions have covered the lost wax process, permanent molding, and metal penetration.—by T. Niven

CENTRAL INDIANA—Joe Cummings, International Harvester Co., left, was technical chairman at a recent meeting. Others are AFS Regional President T. T. Lloyd; speaker J. A. Terpenning, Archer-Daniels-Midland Co., Chapter Chairman Frank Button, Haynes-Stellite Co.; and AFS General Manager W. W. Maloney.—by William R. Patrick

NORTHWESTERN PENNSYLVANIA—Eight foundrymen from W. S. Hodge Foundry Co., Greenville, Pa., attended the opening meeting—by Walter Napp

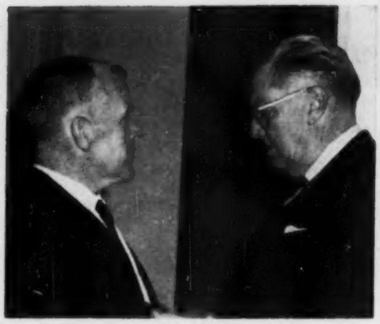
OREGON—William C. Hughes, safety director, Esco Corp., and H. I. Montgomery, Oregon Accident Commission, discuss safety problem—by Bill Walkins

ST. LOUIS—L. L. Randolph, Technical Chairman, and speaker Prof. O. W. Miller, assistant professor of industrial engineering, Washington University, St. Louis, discuss work sampling in the foundry.—by Frank J. Foley

Merle Potter, a 28-year employee of Midwest Foundry Co., Div. L. A. Darling Co., Coldwater, Mich., receives top molding award from A. H. Doerr, vice-president, Darling Co. Midwest Foundry has instituted a competitive point system among production molders. For one month Potter had 100 per cent attendance, a molding scrap of ½ of 1 per cent, and produced 27,723 castings weighing 189,272 pounds.

CENTRAL ILLINOIS—Chapter Chairman H. L. Marlatt, left, Galva Foundry Co., presents past chairman plaque to Clarence J. Turner, Caterpillar Tractor Co. Certificates of appreciation were given to past directors William Thorton, Robert E. Bradley, John Kauzlarich. An AFS certificate for achieving membership quota was given to Edward T. Dunkin, Brass Foundry Co., Peoria, Ill.—by William L. Olsen, Jr.

TWIN CITY—Joe Costello, left, who has retired as pattern superintendent, American Hoist & Derrick Co., shown with Otto Grandl, now pattern superintendent. Costello started with American Hoist in 1924, advancing to pattern superintendent in 1958. He was a charter member of the AFS Twin City Chapter and was chairman. He also served as Chairman of the AFS Pattern Division. Currently is on AFS Committee 8-S.



TEXAS—Howard Heath, Aluminum Co. of America, left, receives congratulations from E. P. Trout. Heath discussed problems in melting and casting aluminum alloys.—by C. Eugene Silver

NEW ENGLAND—A plant visit was made by members to Brown & Sharpe Mfg. Co., Providence, R. I. Shown are Chapter Chairman Lewis W. Greenslade, Jr., and Henry D. Sharpe, Jr., president, Brown & Sharpe—by J. H. Orrok

Central Ohio Chapter

Good and Bad Sand Practice

Various methods of making castings including special techniques were outlined by Clyde Sanders, American Colloid Co., Skokie, Ill. Results comparable to any process can be obtained with green sand if proper methods are followed, he said.

Defects can be caused by strainer cores that break down too easily while good ladle practice is essential to prevent slag inclusions and pinholes. Other observations by Sanders: inoculation can cause a decrease in cell size in gray iron with consequent shrinkage . . . mold wall movement will cause shrinkage which is sometimes attributed to other causes . . . proper ramming, sand temperature, and mulling time all play an important part in producing good castings.

Director John Dusthimer received an award from Chairman N. V. Stapf for leading the chapter to its membership target. — by Russell Marande

CHICAGO—A nuclear method for measuring the moisture content of sand was explained by M. J. Diamond, Central Foundry Div. GMC, right. Making the award is Technical Chairman Joe Semens, U. S. Steel Corp.—by George DiSylvestro

Metropolitan Chapter

Progress in Metalcastings

New trends and processes in the foundry industry were discussed by Jack H. Schaum, editor, MODERN CASTINGS. Eleven instructors of foundry practice in New York and New Jersey schools were guests of the chapter.

Discussed were better materials handling, direct reduction of iron ore to molten iron, control of shakeout for uniform casting properties, fast testing for carbon equivalent, and carbon sand. Schaum predicted some casting techniques that might be common in 1980.

On display was a foundry kit including a small gas melting furnace, flask, sand, and molding tools the chapter is making available to vocational schools. Education Committee Chairman James Silk, Taylor & Co., explained the use of the kit.—by John Steinebach

Eastern Canada Chapter

Holds Diversified Program

Recent meetings have centered around metal penetration and also the lost wax process and permanent molding.

Three speakers discussed metal penetration: J. Dick, Montreal Bronze, Ltd.; L. Fortin, Canada Iron Foundries, and A. E. Murton, Dept. of Mines & Technical Surveys, Ottawa. The technical sessions were held at the Dept. of Mines following a tour.

Permanent mold casting was covered by R. B. Douglas, Specialloid (Canada) Ltd., and R. Obata, Supreme Precision Castings, Ltd., spoke on the lost wax process.—by T. Niven

Central Illinois Chapter
Hot Sands Discussion

Lack of sand volume or the lack of cooling capacity to bring sand temperatures to 100 F. are the chief causes of hot sands, said George DiSylvestro, American Colloid Co., Skokie, Ill.

Chief causes were traced by DiSylvestro to higher production with limited sand cooling capacity, making larger size castings than the foundry is tooled to produce, metal to sand ratio too high, and too many castings to a mold.

When a foundry increases its capacity, a chain reaction normally results, stated DiSylvestro. More molding sand has to be put through the sand conditioning equipment and often mulling time is reduced with a resultant low strength sand at elevated temperature. Moisture and bonds added to give the necessary strength or physical requirements can cause blows, and added moisture can cause stickers and sand to hang in the sand hoppers, and cooling of sands by poorly designed fans or blowers removes fines and metal penetration results.

A recommendation was to add a natural bonded sand at predetermined rates. Natural bonded sands will absorb the extra water used to help cool the hot sands. Other possibilities for cooling are cooling towers or extra storage hoppers and properly designed blowers. Hot sands, said the speaker, will harm the finish and tolerance, shorten tool life, and cause sand grains to fall into the mold cavity due to low hot strength.—by William L. Olsen, Jr.

Western Michigan Chapter
Furan Resin Binders

Techniques and applications for hot and cold furan resin binders were explained by Wayne Buell, Aristo Corp., Detroit. Buell outlined the chemistry, advantages, limitations, and current uses of the binders.—by Herman H. Schreiber

Mo-Kan Chapter
Various Core Practices

Uses and various properties of clays, pitches, linseed oil, core oils, cereals, silicate binder, resins, coldset, hot box, and air cure binders, were discussed by J. A. Gitzen, Delta Oil Products Co., Milwaukee. —by Herman I. Strauch, Jr.

Rochester Chapter
Plastics in Foundries

Strategic use of plastics in patternmaking can produce improved operations, said John Roth, Cleveland Standard Pattern Works. Among advantages mentioned were reproducibility, long life, dimensional stability, superior drawing properties, and lightness. Another advantage is its compatibility with the CO_2 process. Construction of tooling, fixtures, molds, and trimming dies were illustrated with the mating of aluminum and plastic to form the end product.—by J. Deprez

Pittsburgh Chapter
Starts Membership Campaign

A program is well underway for securing an additional 100 members during the current chapter year.

The chapter now has 325 members, the largest in Region 2 and the third largest in the Society. Each member is requested to sponsor a new member. G. E. Smith, G. E. Smith, Inc., is chairman of the membership committee. Other members are John J. Curran, J. G. Buzzard, H. F. McGinnis, W. J. Killian, and H. M. Meinert. — by Walter Napp

Washington Chapter
Use of Melting Equipment

A comparison of furnaces, electric, air, cupola-direct, cupola and electric, and cupola with air furnaces was explained by Charles W. Vokac, Whiting Corp., Harvey, Ill. He also explained types of fuel, carbon range of product, and type of operation.—by James McComb

Twin City Chapter
Explains Communications

You can talk your head off but you do not communicate unless you and the other man share your thoughts, your mental picture and understands, said R. E. Betterley, AFS Education Director.

Other observations by Betterley. "In modern industry, employees can develop a feeling of belonging and security when communications with management are adequate, sincere, and honest. They can become more productive, creating and cooperative where high morale and a feeling of trust exists because of sound communications." — by Matt Granlund

Central Michigan Chapter
Engineering Quality

Foundries can achieve superior castings through the use of an effective quality control program, said Fred G. Sefing, International Nickel Co. He also recommended a pricing standard allowing for uniform quality and minimum rejection losses. Chairman J. E. Grabbert, Gale Mfg. Co., Albion, Mich., presided at the meeting attended by over 50 members.—by R. H. Lambrecht

Washington Chapter
Accuracy Symposium

Dimensional accuracy of castings was discussed by a symposium at a recent meeting. Dick McMichael and Stan Marshall Atlas Foundry & Machine Co., represented corporation pattern shops and foundries. Jim McComb, Peterson Pattern Works and Bruce Howat, Sunset Foundry, represented jobbing shops.—by Jim McComb

AFS Chapter Meetings

DECEMBER 10 - JANUARY 10

Canton District . . Jan. 4 . . Brookside Country Club, Barberton, Ohio . . *Panel Discussion.*

Central Illinois . . Jan. 8 . . Vonachen's Junction, Peoria, Ill. . . A. J. Paul, Caterpillar Tractor Co., *"Why Castings?"*

Central Indiana . . Jan. 8 . . Athenaeum Club, Indianapolis . . J. B. Caine, *"Casting Design."*

Central Ohio . . Dec. 11 . . Maennechor Club, Columbus, Ohio . . A. J. Stone, Battelle Memorial Institute, *"Alloying of Gray Iron."*

Chicago . . Jan. 8 . . Chicago Bar Association, Chicago . . W. E. Haskell, U. S. Steel Corp., *"Why Profit?"*

Cincinnati District . . Dec. 23 . . Netherlands Hilton Hotel, Cincinnati . . *Annual Christmas Party.*

Cincinnati . . Jan. 8 . . Engineers' Club, Dayton, Ohio . . R. K. Guise, Kuhns Bros. Co. *"Cupola Injection"* . . Dr. Keith Wilkle, Brush Beryllium Co., *"Founding & Applications of Copper & Nickel-Base Beryllium Alloys."*

Connecticut . . Dec. 13 . . Waverly Inn, Cheshire, Conn. . . *Annual Christmas Party.*

Corn Belt . . Dec. 16 . . Lincoln, Nebr. . . *Christmas Party.*

Eastern New York . . Dec. 12 . . Rafael's Restaurant, Lathan, N. Y. . . *Christmas Party.*

Metropolitan . . Jan. 8 . . Military Park Hotel, Newark, N. J., R. Sinclair, Roger Sinclair Associates, *"An Engineering Approach to Casting Pricing and Cost Control."*

Michiana . . Dec. 11 . . Club Normandy, Mishawaka, Ind. . . E. J. Walsh, Foundry Educational Foundation, *"Foundry Education Foundation — What It Is—What It Does."*

Michiana . . Jan. 8 . . Club Normandy, Mishawaka, Ind. . . Erick Welander, John Deere Malleable Works, *"Ductile Iron."*

Mid South . . Dec. 22 . . Claridge Hotel, Memphis, Tenn. . . *Christmas Party.*

New England . . Jan. 10 . . University Club, Boston . . Roger Sinclair, Roger Sinclair Associates, *"Cost Control."*

Northern California . . Dec. 11 . . Hotel Lake Merritt, Oakland, Calif. . . J. L. Francis, Micro Metals Inc., *"Shell Cores, Molds And Equipment."*

Northern Illinois & Southern Wisconsin . . Jan. 9 . . Elks Club, Beloit, Wis., George DiSylvestro, American Colloid Co., *"Veining and Penetration."*

Oregon . . Dec. 16 . . Multnomah Hotel, Portland, Ore. . . *Annual Christmas Dinner Dance.*

Philadelphia . . Dec. 12 . . Ben Franklin Hotel, Philadelphia . . *Christmas Party.*

Pittsburgh . . Dec. 11 . . Penn-Sheraton Hotel, Pittsburgh, Pa. . . *Annual Christmas Party.*

Saginaw Valley . . Jan. 4 . . National Officers' Night . . Speakers From Area Foundries, *"Safety Practices in Saginaw Valley Foundries."*

St. Louis District . . Dec. 14 . . Edmonds Restaurant, St. Louis . . George Koren, Beardsley & Piper, *"Core Room Binders."*

Toledo . . Jan. 3 . . Globe Hotel, Toledo, Ohio . . H. D. Merchant, *"Gating and Risering of Castings."*

Twin City . . Jan. 9 . . Jax's Cafe, Minneapolis . . Col. H. A. Schon, Director of Civil Defense, State of Minnesota, *"Civil Defense For Industry."*

Future Meetings and Exhibits

Dec. 1 . . Malleable Founders Society, Semi-Annual Meeting, Hotel Sheraton, Cleveland.

Dec. 6-8 . . American Institute of Mining, Metallurgical and Petroleum Engineers, Electric Furnace Conference, Penn-Sheraton Hotel, Pittsburgh, Pa.

Feb. 15-16 . . Southeastern Regional Foundry Conference, Tutwiler Hotel, Birmingham, Alabama.

Feb. 8-9 . . Wisconsin Regional Foundry Conference, Hotel Schroeder, Milwaukee.

Feb. 28-Mar. 1 . . Malleable Founders Society, 7th Annual Technical and Operating Conference, Hotel Pick Carter, Cleveland.

March 12-13 . . Steel Founders' Society of America, annual meeting, Drake Hotel, Chicago.

March 15-16 . . Texas Regional Foundry Conference, Menger Hotel, San Antonio, Texas.

Apr. 9-13 . . American Welding Society, Annual Meeting and Welding Exposition, Hotel Sheraton, Cleveland.

Apr. 17-19 . . American Society For Metals, Regional Conference and Exhibition, Shamrock Hilton Hotel, Houston, Texas.

May 7-11, 1962 . . AFS 66th Annual Castings Congress and Exposition, In conjunction with The 29th International Foundry Congress . . Cobo Hall . . Detroit.

May 28-29 . . Malleable Founders Society, Annual Meeting, The Homestead, Hot Springs, Va.

June 24-29 . . American Society For Testing and Materials, Annual Meeting, Statler Hotel, New York.

Oct. 4-6 . . Non-Ferrous Founders' Society, Annual Meeting, The Broadmoor, Colorado Springs, Colo.

Mueller Industries Centers Headquarters in Milwaukee

Mueller Industries Inc., which operates foundry and machining plants in three states, is centralizing its operations in Milwaukee. The move will make Milwaukee headquarters for sales, accounting, engineering, production control, and quotations procedures according to A. J. Mueller, newly elected president.

Two operations are in Milwaukee, Love-Brothers-Pyott Div., and Badger Malleable Div. Midwestern Foundries, Inc., and Sterling Casting Corp., are located in Garret and Bluffton, Ind., and the Love-Brothers-Pyott Machining Div. is located at Aurora, Ill.

Howe Sound Buys Steel Foundry

Howe Sound Co., New York, has acquired for an undisclosed amount of cash Pennsylvania Electric Steel Casting Co., Hamburg, Pa. The acquisition includes purchase of all plant facilities and inventory. It will be operated as a division with the same name and management under the direction of R. A. McBride, president of the Milwaukee-based Crucible Steel Casting Co., another Howe division.

Sterling Aluminum Products Starts Carmi, Ill. Plant

Sterling Aluminum Products, Inc., St. Charles, Mo., has started production in their newly acquired facilities at Carmi, Ill. The addition increases Sterling and its subsidiaries annual capacity by 120,000,000 pounds of permanent mold aluminum castings, bringing the total capacity to 110,000,000 pounds.

Metalcasters in the News . . .

Dr. Le Roi E. Hutchings . . . named associate director of research for Great Lakes Carbon Corp., and will be located at the research center at Morton Grove, Ill.

Robert A. Lubker . . . elected as vice-president of research and development, Alan Wood Steel Co.

Alvin J. Herzig . . . president, Climax Molybdenum Co. of Michigan, a subsidiary of American Metal Climax, Inc., has been awarded a top medal award for advancement of research during 1961 by the American Society for Metals.

Donald B. Bartz . . . named as chief engineer, Whirl-Air-Flow, Minneapolis, Minn.

Cecil DeLange . . . promoted to Chicago district sales force of Whiting Corp., Harvey, Ill. **J. S. Deacon** has joined Whiting Corp. He will also work from the Chicago office.

J. J. Kroecker . . . named vice-president in charge of sales by Permold Co., Medina, Ohio, succeeding **L. E. DeGroat** who has retired.

Ralph P. Gates . . . promoted to director of technical services, Victor Chemical Works Div., Stauffer Chemical Corp., succeeding **L. E. Jackson** who has retired.

Irwin J. Lubalin . . . named executive vice-president, Shaw Process Development Corp., Div. Avnet Electronics Corp., Port Washington, N. Y. He is also a vice-president of British Industries Corp., a division of Avnet.

John A. Morrison, Jr. . . . is a field sales engineer, Gries Reproducer Corp., New Rochelle, N. Y.

James W. Volk . . . Michigan City, Ind., is now executive vice-president, Brillion Iron Works, Inc., Brillion, Wis. He has been president and general manager of Michiana Products Co., Michigan City and vice-president of Berliana Corp., Chicago.

Albert J. Buckenmeyer . . . named treasurer and **Donald M. Smith** controller of Midland-Ross Corp., Cleveland.

Roy A. Jacobson . . . vice-president Carondelet Foundry Co., St. Louis, has retired. He had been with Carondelet for more than 30 years and an officer and director for the past 20. Jacobson has completed 60 years of association with the foundry industry, having started as a foundry and pattern apprentice in 1901. Afterwards he started his own pattern business which was sold in 1921, and became active in the management of Commercial Foundry and Green Foundry of St. Louis.

Paul R. Rothery, Jr. . . . has joined Bay State Refining Co., Chicopee Falls, Mass., and will assist in the company's management.

Charles H. English . . . is marketing manager, International Div., Basic Products Corp., Milwaukee.

S. A. Kundrat . . . is plant manager, United Bronze of Pittsburgh, Pittsburgh, Pa. Since the death of **Milton G. Lehman,** production was under the direction of **Mrs. Claire Orringer,** secretary and treasurer. The company is expanding into aluminum, monel and precision cast bronze casting production.

Earle G. Benson . . . elected president of A. J. Boynton & Co., Chicago, engineers and technical counselors. **J. B. Eberlein** and **J. H. Greenberg** have been elected to two newly created posts of vice-president. **S. H. Jones** is also a vice-president.

Charles R. Yoh . . . is assistant to the technical director, Gray Iron Founders' Society, Cleveland. He was formerly with National Castings Co., Cleveland.

Paul E. Smith . . . is now vice-president of sales, Chase Foundry & Mfg. Co., Columbus, Ohio. He was formerly chief engineer and purchasing agent.

Roger L. Hosfield . . . has joined Hevi-Duty Electric Co., Div. Basic Products Corp., Watertown, Wis., as product manager of its oven division. **Henry Lutgen,** formerly oven product manager, is now applications engineer for large field-erected ovens.

Ralph H. Hoefs . . . appointed as chief metallurgist of the Chain Belt Co. research center in Milwaukee.

Howard Strandberg . . . appointed assistant general manager of the Refractories Div., H. K. Porter, Inc. He was previously the division's New York district sales manager.

Robert E. Morken . . . is now product manager in charge of melting furnace engineering and sales for Hevi-Duty Electric Co., Div. Basic Products Corp., Milwaukee. Hevi-Duty is adding a new line of low-frequency induction furnaces.

Robert F. Morgan . . . is now a member of the Detroit sales staff of Pangborn Corp., Hagerstown, Md.

Don H. Taylor . . . has joined Wheelabrator Corp., Dust & Fume Control Div., Mishawaka, Ind., as a regional engineer and has been assigned to a territory in northern Ohio and Michigan including the cities of Cleveland and Detroit.

Frederick C. Irving, Jr. . . . appointed to the newly created position of engineered products sales, Aluminum Co. of America, Pittsburgh, Pa.

William F. Rogge . . . a vice-president of Aeroquip Corp., Jackson, Mich., now heads a newly formed division which includes all of the company's industrial products manufacturing and marketing activities in the U.S., except for the Marman Div. in Los Angeles.

Curt Searight . . . appointed regional sales manager with headquarters at Mexico, Mo., for Kaiser Refractories Div., Kaiser Aluminum & Chemical Corp. He will be responsible for the St. Louis, Rock Island, and Indianapolis districts. **Lloyd Brinkman** succeeds Searight as district manager in the St. Louis area.

Ralph W. Walker . . . named sales engineer for WaiMet Alloys Co., Div. Howe Sound Co., Dearborn, Mich.

Davis G. Taylor . . . is now a sales

engineer with Pangborn Corp. West Coast Div. and will operate out of Alamo, Calif.

W. W. Thomas . . . appointed to newly-created position of foundry sales engineer for the Watertown Div., New York Air Brake Co., Watertown, N. Y.

Dr. Alexander Ross . . . appointed European technical representative for M&T Chemicals, AG. He will headquarter in Zug, Switzerland.

Alex J. Szabo . . . is now a sales engineer, Cleveland district, for Pangborn Corp., Hagerstown, Md. He had previously been a supervisor in the Vibratory Finishing Div.

Leonard W. Mawhinney . . . is a vice-president, Metal & Thermit Corp., New York. Other changes: **R. A. Bernabo** elevated to corporate secretary, and **E. J. Robesch** is assistant controller and assistant secretary.

Harry J. Bolwell . . . elected as vice-president of Midland-Ross Corp. and general manager of the company's Surface Combustion Div., succeeding **Eugene P. Heiles** who will retire soon.

Joe L. Miller, Sr. . . . has formed his own business located at 18 Cool Ridge Rd., Milford, Conn. He operates as a refractory consultant, supervisor, and manufacturers' representative.

Ernest W. Horvick . . . named director of technical services for American Zinc Institute, New York. He has been a member of the A.Z.I. market development staff for the past nine years.

Robert J. Young . . . elected president of Hill Hubbell Co., subsidiary of National Castings Co., Cleveland.

Lyman D. Ketchum . . . named sales manager for General Foods' Corn Mill operations at Kankakee, Ill., succeeding **Ross Barzelay** who becomes operations manager.

Graham B. Brown . . . has joined Stauffer Chemical Co. as general manager, Metals Div. He will be located at division headquarters in Richmond, Calif.

Ralph Huft . . . named assistant general manager, Foundry Div., Hills-McCanna Co., Chicago.

R. A. Wanty . . . appointed sales engineer covering the state of Michigan for the Elyria Foundry Div., Chromalloy Corp., Elyria, Ohio.

Melvin D. Gerald . . . is manager, Foundry Div., Benthall Machine Co., Suffolk, Va.

Deaths

Martin Fladoes . . . 65, board chairman of the Sivyer Steel Castings Co., Milwaukee. He served as an AFS National Director and a director of the Steel Founders' Society of America, and on the Steel Casting Advisory Board during World War II.

Advertised Products
December—1961

(Continued next page)

"One Stop" Service for Metalcasters

On this page you will find an alphabetical reference guide to products, processes, and services offered by advertisers of MODERN CASTINGS. In the same column you will see the names of the advertisers offering the service and the page number of the ads.

This is designed as a "one stop" reference for busy metalcasters in search of important information. Each advertiser has prepared this important material with you in mind. Keeping well-informed is essential in today's highly competitive market.

Another important step to increase your "one stop" reading is the merging of "New Products and Processes" and "For the Asking" into a single, easy-to-read section entitled "Metalcasting Products and Processes."

Use the handy Reader Service Card below to build a valuable reference file of new products, processes, and techniques. The manufacturers who participate in this section are eager to send data to any qualified reader of MODERN CASTINGS.

DECEMBER 1961—1

Valid through Feb. 1962

NEW EQUIPMENT AND LITERATURE										ADVERTISED PRODUCTS							
1	13	25	37	49	61	73	85	97	109	121	133	145	157	169	181	193	205
2	14	26	38	50	62	74	86	98	110	122	134	146	158	170	182	194	206
3	15	27	39	51	63	75	87	99	111	123	135	147	159	171	183	195	207
4	16	28	40	52	64	76	88	100	112	124	136	148	160	172	184	196	208
5	17	29	41	53	65	77	89	101	113	125	137	149	161	173	185	197	209
6	18	30	42	54	66	78	90	102	114	126	138	150	162	174	186	198	210
7	19	31	43	55	67	79	91	103	115	127	139	151	163	175	187	199	211
8	20	32	44	56	68	80	92	104	116	128	140	152	164	176	188	200	212
9	21	33	45	57	69	81	93	105	117	129	141	153	165	177	189	201	213
10	22	34	46	58	70	82	94	106	118	130	142	154	166	178	190	202	214
11	23	35	47	59	71	83	95	107	119	131	143	155	167	179	191	203	215
12	24	36	48	60	72	84	96	108	120	132	144	156	168	180	192	204	216

Please Print and Fill Out Completely to Validate Your Requests

Name

Position

Company

Address

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY CARD
First Class Permit No. 83, Sec. 34.9, P. L. & R.
DES PLAINES, ILL.

Reader Service Dept.
MODERN CASTINGS
Golf and Wolf Rds.
Des Plaines, Ill.

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DECEMBER 1961—2

Valid through Feb. 1962

NEW EQUIPMENT AND LITERATURE | **ADVERTISED PRODUCTS**

1	13	25	37	49	61	73	85	97	109	121	133	145	157	169	181	193	205
2	14	26	38	50	62	74	86	98	110	122	134	146	158	170	182	194	206
3	15	27	39	51	63	75	87	99	111	123	135	147	159	171	183	195	207
4	16	28	40	52	64	76	88	100	112	124	136	148	160	172	184	196	208
5	17	29	41	53	65	77	89	101	113	125	137	149	161	173	185	197	209
6	18	30	42	54	66	78	90	102	114	126	138	150	162	174	186	198	210
7	19	31	43	55	67	79	91	103	115	127	139	151	163	175	187	199	211
8	20	32	44	56	68	80	92	104	116	128	140	152	164	176	188	200	212
9	21	33	45	57	69	81	93	105	117	129	141	153	165	177	189	201	213
10	22	34	46	58	70	82	94	106	118	130	142	154	166	178	190	202	214
11	23	35	47	59	71	83	95	107	119	131	143	155	167	179	191	203	215
12	24	36	48	60	72	84	96	108	120	132	144	156	168	180	192	204	216

Please Print and Fill Out Completely to Validate Your Requests

Name

Position

Company

Address

Advertised Products December—1961 (cont.)

New Metalcasting Equipment and Processes

What's new in foundry methods and equipment? Summaries of the latest news from manufacturers and suppliers are presented below. For more complete information, circle the corresponding number on the free postcard on page 133. Mail it to us; we'll do the rest.

Equipment

Twin beam betatron tube . . . cuts inspection time in industrial radiography by exposing two films at once. Twin, parallel beams are produced by injecting two streams of electrons into the betatron tube rather than a single stream. The two streams, one oriboting clockwise, the other counterclockwise, each strikes a target at opposite sides of the betatron tube to produce separate sources of x-rays. Allis-Chalmers Mfg. Co.

Circle No. 1, Pages 133-134

Dust collector . . . designed to meet wide variety of air volume requirements is described in four-page folder. Pangborn Corp.

Circle No. 2, Pages 133-134

Hot-box core production unit . . . may be used by any type foundry for any core making job that justifies metal core box equipment. Utilizes side blow to provide a fast full-pressure blow for intricate work in wide range of core boxes up to 15⅝ by 20 in. Semi-automatic in operation. Beardsley & Piper Div., Pettibone-Mulliken Corp.

Circle No. 3, Pages 133-134

Hevi-duty standard crane . . . available in capacities from five to 30 tons described in brochure. Whiting Corp.

Circle No. 4, Pages 133-134

New gas burner . . . for reverbatory furnace is a sealed in, hinged-type for oil or gas. Burner can be easily withdrawn from burner tuyere immediately at shut-down. A feature is elimination of passing air through the burner after shut-down to prevent burner internals from deteriorating. U. S. Smelting Furnace Co.

Circle No. 5, Pages 133-134

Sander adapter . . . shortens the time to set up to spin a boss or circle on any make of disk sander having a slot on the table. Reportedly maintains accuracy within several thousands of an inch. Schnorberger & Associates.

Circle No. 6, Pages 133-134

Double disk casting grinding . . . reportedly made possible with new technique involving no magnetism. Powerad Co.

Circle No. 7, Pages 133-134

Aluminum melting furnace . . . low frequency induction type, is being manufactured in U. S. under license from Forni Electtrici A. Tagliaferri of Italy. Hevi-Duty Electric Co.

Circle No. 8, Pages 133-134

Induction power source . . . utilizes a static frequency-multiplying circuit that converts a balanced 3-phase, 60-cycle power input to a 180-cycle output. Said to offer advantages of lower installation and maintenance costs as well as improved performance. Inductotherm Corp.

Circle No. 9, Pages 133-134

Refractory ramming and gunning . . . mixes are now shipped in a new, self-dispensing, hopper bottom container. Designed for use by lift truck for positioning over mixer or gun. A 2000-lb capacity gun can be filled in three minutes. Kaiser Refractories Div., Kaiser Aluminum & Chemical Corp.

Circle No. 10, Pages 133-134

Hydraulic rotary torque actuators . . . convert hydraulic pressure into mechanical torque. Offer angular rotation to 200 degrees. Torque remains constant regardless of the shaft angular position. Operate on pressures up to 5000 psi with a low flow of hydraulic fluid. Menasco Mfg. Co.

Circle No. 11, Pages 133-134

Triple-scissor lift . . . for personnel has an extended height of eight feet, bringing racks 14 feet high within reach of operator. Elimination of superstructure permits working of both sides of aisle. Southworth Machine Co.

Circle No. 12, Pages 133-134

Lab moldability tester . . . employs a screen for measuring moldability of sand in terms of an index. Tester is an inclined, cylindrical screen driven by a fractional horsepower motor. Screening time is controlled by push-button dial timer with automatic reset. A 200-gram sample is placed in screen cylinder and rotated for 10 sec. Sand falling through screen is collected and weighed, indicating moldability index. Harry W. Dietert Co.

Circle No. 13, Pages 133-134

Induction heating equipment . . . eight-page catalog, covers line, including 60-cycle furnaces, frequency converters and accessories, high frequency melting equipment, vacuum melting and degassing equipment, etc. Ajax Magnethermic Corp.

Circle No. 14, Pages 133-134

Filter-collector . . . offers quick, individual tube changing in dust collection. Construction permits removal of individual cage and sock assemblies and immediate replacement of completely assembled spare units. Young Machinery Co.

Circle No. 15, Pages 133-134

Fluidized beds . . . bulletin describes equipment for heat processing, including annealing, normalizing, solutionizing, aging, hardening, quenching, and isothermal transforming. General Electric Co.

Circle No. 16, Pages 133-134

Crane safety limit stops . . . break power circuit directly, provide d-c dynamic braking on d-c cranes. Bulletin outlines details. Euclid Electric & Mfg. Co.

Circle No. 17, Pages 133-134

Suspended separation magnets . . . in various sizes, strengths, and styles are outlined in eight-page bulletin. Stearns Magnetic Products.

Circle No. 18, Pages 133-134

Lifting magnets . . . bulletin, 8 pages, lists over 50 styles and types of circular and rectangular types. Includes cutaway views, capacity and dimensional charts, and helpful guide to selection. Stearns Mag-

netic Products Div., Indiana General Corp.

Circle No. 19, Pages 133-134

Continuous mixers . . . in single and double shaft models, can handle up to 100 tons per hour. Fourteen standard sizes available, also custom units. Falls Industries, Inc.

Circle No. 20, Pages 133-134

Ultrasonic ball point . . . writing instrument requires no writing fluids or marking compounds. Writing is as permanent as the paper. Reportedly able to operate in all types of atmospheres. May be used for strip or chart recording. Ultrasonic Industries, Inc.

Circle No. 21, Pages 133-134

Thermocouple wire . . . and cable catalog gives prices and ordering information on over 150 standard items. Claud S. Gordon Co.

Circle No. 22, Pages 133-134

Conveyors . . . including portable, hinged-sheet belt, and custom models are outlined in 8 page bulletin. Contains special engineering section. May-Fran Mfg. Co.

Circle No. 23, Pages 133-134

Radiant type gas burners . . . bulletin 18 pages, presents full line of "complex premix" units. Covers design features, construction, operating principles, and advantages. Selas Corp. of America.

Circle No. 24, Pages 133-134

Bulk transport trailer . . . handles silica sand, makes it possible to unload and elevate sand to height of 50 ft. or more pneumatically. Unload rate averages 1 ton of silica sand per min. Has capacity of 720 cubic ft. Whirl-Air Flow.

Circle No. 25, Pages 133-134

Aerosol coding compound . . . has coating that adheres tightly over grime and grease without loss of color or brightness. No pre-cleaning is required. Perc E. Harms Co.

Circle No. 26, Pages 133-134

Shop equipment catalog . . . 52 pages, includes wide selection of new and used material handling and storage equipment plus a full line of all-steel office furniture and accessories. Industrial Handling Equipment Co.

Circle No. 27, Pages 133-134

Flexible metal hose connectors . . . described in 4-page bulletin. Engineered to meet common vibration, expansion, and misalignment conditions. Atlantic Metal Hose Co.

Circle No. 28, Pages 133-134

Gas burners . . . 4-page bulletin describes extension of available sizes of air-gas burners to ¾ in. to 6 in. air pipe sizes. Features turndown ratio of 45:1. North American Mfg. Co.

Circle No. 29, Pages 133-134

Lightweight abrasive blaster . . . allows operation by one man in inaccessible places and for small jobs. Can be pulled on own wheels or carried. Automatic controls available. Andersen Mfg. Co.

Circle No. 30, Pages 133-134

Supplies

Preformed ceramic cores . . . for investment castings permits design freedom. Four-page bulletin outlines evaluation of cores for such factors as dimensional stability, surface finish, casting temperatures, thermal shock resistance, compatability with casting alloys, and size. Sherwood Refractories.

Circle No. 31, Pages 133-134

Laboratory supplies, equipment . . . described in 936 page catalog. Items listed alphabetically by names in common usage. LaPine Scientific Co.

Circle No. 32, Pages 133-134

High temperature ceramics . . . are covered in 32-page catalog. Contains detailed information on space-age ceramic compositions such as alumina, magnesia, thoria, zirconia, and others. Laboratory Equipment Corp.

Circle No. 33, Pages 133-134

Southern bentonite . . . properties, uses, and typical analysis are contained in four-page bulletin. Magnet Cove Barium Corp.

Circle No. 34, Pages 133-134

Molybdenum and copper . . . in corrosion resistant steels and alloys is outlined in 60-page booklet. Contains tables, charts, graphs, and photographs. Climax Molybdenum Co., Div. American Metal Climax, Inc.

Circle No. 35, Pages 133-134

Investment casting . . . speeded through use of extruded wax shapes. Has high tensile strength and flexibility over a wide range of seasonal temperatures. Alexander Saunders & Co.

Circle No. 36, Pages 133-134

Asbestos board insulation . . . has good moldability and high resistance to sudden impact of flame or molten metal. Four-page brochure contains illustrations and technical data. Johns-Manville.

Circle No. 37, Pages 133-134

Foundry carbide . . . a cupola additive, aids both acid and basic melting of gray or ductile iron. One per cent by weight of metal charge raises iron temperatures 50-60 degrees. Union Carbide Metals Co., Div. Union Carbide Corp.

Circle No. 38, Pages 133-134

Coated sands . . . production explained in 6-page brochure. Describes methods used by one processor. Durez Plastics Div., Hooker Chemical Corp.

Circle No. 39, Pages 133-134

Electron beam melting . . . of metals and alloys is covered in four-page bulletin. Experimental alloys available on a developmental basis. Stauffer Metals Div., Stauffer Chemical Co.

Circle No. 40, Pages 133-134

Machine tool and accessories . . . catalog, 48 pages, describes complete line. Complete specifications, catalog listings and descriptions of accessories for all tools are included. Rockwell Mfg. Co., Walker-Turner Div.

Circle No. 41, Pages 133-134

Interchangeable respiratory protection . . . available with one facepiece and variety of filter and chemical cartridges for protection against dust, radioactive particulate, metal fumes, organic vapors, acid gases, ammonia, and other airborne hazards. Four-page folder gives details. Mine Safety Appliances Co.

Circle No. 42, Pages 133-134

Tooling plastics . . . for foundries covered in eight-page booklet. Shows uses in blow boxes, matchplates, cope and drag patterns, and other uses. Furane Plastics, Inc.

Circle No. 43, Pages 133-134

Non-destructive testing . . . principles covered in 12-page brochure Magnaflux Corp.

Circle No. 44, Pages 133-134

Classified Advertising

For Sale, Help Wanted, Personals, Engineering Service, etc., set solid . . 35c per word, 30 words minimum prepaid. Positions Wanted . . 10c per word, 30 words minimum, prepaid. Box number, care of Modern Castings, counts as 10 words. Display Classified . . Based on per-column width, per inch . . 1-time, $22.00 6-time, $20.00 per insertion; 12-time, $18.00 per insertion; prepaid.

HELP WANTED

GENERAL SUPERVISOR wanted to head up scrap control program in Indiana gray iron foundry. Send resume and expected salary to: Box I-104 H, MODERN CASTINGS, Golf and Wolf Roads, Des Plains, Ill.

Leading manufacturer of Foundry Sand Conditioning Equipment is interested in aggressive SALESMAN calling on foundries in Michigan. Should be familiar with sand handling system layout and have good foundry following. Reply in detail to Box L-104 H, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.

METALLURGICAL SALES ENGINEER for field service work to represent old line manufacturer of Ferrous Foundry Riser and Hot Top Compounds. Extensive traveling necessary. Offer fully paid Pension, Insurance, and other benefits. Excellent Opportunity—Write Box L-102 H, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.

REPRESENTATIVES WANTED—One of the nation's leading Ductile Iron, Gray Iron, Brass and Aluminum Foundries needs more representatives. Send resume and advise area desired. Box L-103 H, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.

FOUNDRYMEN

Production • Sales • Management

Where do you stand in the Foundry Industry? Does your income equal your ability? Find out by contacting, without obligation, the nation's leading placement service.

Foundry Companies also find Cadillac's confidential service without equal in securing the right man for the right job.

For prompt action contact

John Cope

Cadillac Associates, Inc.

29 East Madison Bldg., Chicago 2, Ill.
Financial 6-9400

FOUNDRY ENGINEER with minimum of five years experience in the technical aspects of non-ferrous foundry operations. Excellent opportunity for a progressive individual to get in on the ground floor of a dynamic growth company. Salary open. Please give full details of qualifications, experience, salary range, and availability in first letter. All inquiries will be held in strict confidence. Address Box L-100 H, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.

FOUNDRY SALESMAN—Large Gray Iron Foundry in New England needs foundry salesman for New Jersey and Pennsylvania area. Must have sales and Gray Iron Foundry experience. Salary open. Box L-105 H, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.

POSITION WANTED

METALLURGIST, age 44, eight years experience in foundry and heat-treating of magnetic alloys. Eight years with large alloy steel company. Supervisory experience in induction melting, heat treating, inspection and quality control. Desires position with challenge and opportunity for future. Address Box L-101 P, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.

FOR SALE

QUALITY EQUIPMENT
SAVE AT LEAST 50%

Blast Cleaning
15" cont. Wheelabrator Tumblast
36" x 42" Wheelabrator Tumblast
19GN Pangborn Blastmaster Late

Furnaces
3000# Detroit Ind. Arc. Mltg.
Large Stock of Annealing Furnaces
1½ Ton Arc Melting Furnace
500# Induction Melting Inst.

Sand Mullers
Simpson #3, U.D., 30 cu. ft.
Simpson #2, U.D., 14 cu. ft.

Complete stock of foundry equipment. Send for free illustrated catalog.
UNIVERSAL Mach'y & Equip't Co.
Box 873, Reading, Pa. FRanklin 3-5103

Metallurgical Fraternity Adds Three New Chapters

Three new chapters have been admitted to Alpha Sigma Mu, national honorary metallurgical fraternity. The chapters are at Case Institute of Technology, Cleveland; University of Alabama, Tuscaloosa, Ala.; and Rensselaer Polytechnic Institute, Troy, N. Y.

Other chapters are located at University of Illinois, Virginia Polytechnic Institute, Missouri School of Mines, Wayne State University, University of Maryland, New York University, and Brooklyn Polytechnic Institute.

In its 29 years of existence, Alpha Sigma Mu has grown to 1072 members, with considerable growth during the past two years. Membership is restricted to metallurgy students whose academic standing places them in the upper 25 per cent of their class. The fraternity was originally formed on the campus of Michigan College of Mining & Technology in 1932.

In addition to the eleven schools which have fraternity chapters on their campuses, numerous other schools have nominated their outstanding metallurgy schools for Alpha Sigma Mu membership.

Advertisers This Issue

The Editor's Forum . . . . .

The Continental look . . . is starting to creep into U. S. foundries. Electric furnaces —common in European gray iron foundries— are beginning to catch on over here. Enthusiasm is running high at Sibley Machine & Foundry Corp., South Bend, Ind., as the result of their recent installation of an Italian make induction receiver. Cupola iron is transferred to the 8800 pound capacity induction unit where it is refined, superheated, and alloyed when necessary.

No one is more enthusiastic about the future benefits from this $50,000 investment than John McIntyre, president of Sibley. As he held a power steering valve body in his hand, he explained to me that the 8000-a-day order they now had in the plant could be attributed entirely to their new induction receiver. "Pressure from our customers and competing materials" says Sibley "are forcing us to improve our foundry practices."

Metal run through the receiver has shown an increased tensile strength, better machineability, tighter grain, finer graphite, narrower hardness range, and greater reliability. With these capabilities you can be sure Sibley will be out in front penetrating new markets and helping establish the new quality image we need so desperately in the metalcasting industry.

Modern materials handling devices . . . may seem to some another luxury for the foundry. But Ray Haywood of Draper Corp. points out that the incidence of back injuries in foundries has decreased 63 per cent—thanks to substituting mechanization for muscles. What's more, molders can now stay on their molding jobs until they reach retirement age. It doesn't take many back injuries and premature disability retirements to exceed the cost of materials handling equipment. The accidents that cease to happen contribute just as much to the profit picture as do some of the gains in productivity.

Eye injuries . . . can be reduced if workers stop in the first aid room after work and have the nurse wash out their eyes. Charlie Mooney tells about this precautionary practice used at Link Belt's Olney Foundry. Any cleaning room employee working on an unusually dusty chipping operation is required to have an eye wash. Safety goggles stop injuries from flying chips, but insidious abrasive dust often manages to sneak past this guard. Hours later, when the worker is home, he starts to rub his eyes and serious inflammation can result. The stitch-in-time . . .

Metalcasters are criticized . . . severely for not delivering their message to the right audience. They talk to themselves too much! So it's encouraging to hear four excellent talks presented by foundrymen at the recent "Heavy Duty" Vehicle Meeting of the Society of Automotive Engineers in Milwaukee. Morris Bean and Lawson March of Morris Bean & Co., A. H. Hinton of Aluminum Co. of America, John Lapin of Central Foundry Div., GMC, and Richard Stenberg of Outboard Marine Co. championed the merits of metalcasting before an audience that makes the decisions on the materials and fabrications which will be used tomorrow.

If smoking molds . . . are a problem in your foundry take a lesson from Crouse-Hinds in Syracuse. Bothered by excessive smoke evolution from shell cores when pouring gray iron, Bob Shea, foundry engineer, solved the problem completely and easily. While in their shop recently, Bob showed me how they rigged a gas pipe along side of the pouring loop so the smoke from each mold is ignited as it passes the flaming torch aimed at parting line. Once ignited that eye, nose, and throat irritation is consumed by fire. This source of personal discomfort is converted to odorless CO_2 and water vapor and everyone in the general working area is considerably happier.

Jack H Schaum

LOOK WHAT CALCIUM ALLOYS CAN DO

for steel foundries...

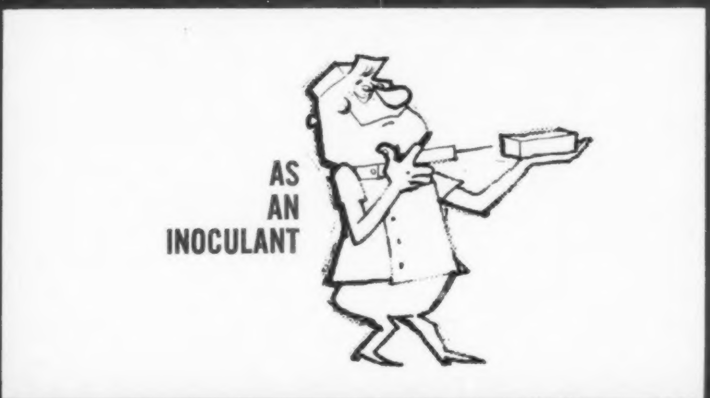
Ohio Ferro-Alloys' calcium alloys are beneficial in the production of quality steel and iron castings.

Steel foundries find the deoxidizing and degassifying effects of calcium-silicon and calcium-manganese-silicon produce cleaner castings. Undesirable inclusion types are greatly reduced or eliminated.

Cleaner metal results in better properties for steel castings. Marked improvements in ductility and impact properties have been widely noted.

Calcium treated cast steel exhibits improved fluidity. For consultation on how calcium-silicon and calcium-manganese-silicon may help your castings, contact our Foundry Service Department.

for iron foundries...



In cast iron, too, the calcium alloys help produce better castings. Inoculation of gray cast iron with calcium-silicon prevents chilled edges and improves machinability.

QUALITY DEPENDABILITY SERVICE

Ohio Ferro-Alloys Corporation
Canton, Ohio

BIRMINGHAM • BOSTON • CHICAGO • DAYTON • DENVER • DETROIT • HOUSTON • KANSAS CITY • LOS ANGELES • MINNEAPOLIS
PHILADELPHIA • PITTSBURGH • ST. LOUIS • SALT LAKE CITY • SAN FRANCISCO • SEATTLE • TONAWANDA, N.Y.

HOUGHTON *FOUNDRY SAND BINDERS*

New development in sand binders can put the magic of catalytic polymerization to work in your foundry

CURES "READY-TO-POUR" IN 6 TO 8 HOURS WITH NO BAKING. PRODUCES NO IRRITATING FUMES.

New Quik-Sett NB is a concentrated furan-type resin binder for large sand molds and cores that cure thoroughly at room temperature. Sand surfaces are exceptionally smooth and hard, producing excellent surfaces on castings. Because it cures by catalytic polymerization, without oxidation or baking, handling is reduced to a minimum—time and money are saved.

No irritating fumes

Most furan-type binders available to date have produced a strong, irritating formaldehyde odor because the formaldehyde was loosely combined with the resin. This objectional characteristic has been eliminated in Quik-Sett NB through precise resin control and special compounding procedures. The result is a concentrated resin that produces no persistent odor during working and curing.

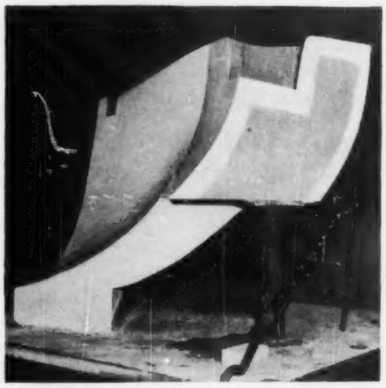
Cores and molds made easier and faster

Total mulling time is only 2 to 7 minutes producing a mix with excellent flow characteristics. Because the mix flows readily, no ramming is required in setting up the core or mold. Little more than hand tucking is needed to fill all voids in the pattern.

Since cores and molds of Quik-Sett NB have superior early strength, rodding is drastically reduced. Usually only a bottom and top web, to anchor hooks, is ample.

Other features of Quik-Sett NB

- Simplified binder-catalyst process
- Fast, controlled curing
- Low gas content eliminates pin holes
- Surface density minimizes penetration or burn-in
- Accurate dimensional stability
- Excellent storage characteristics



This huge core, made with Quik-Sett NB and weighing 1250 lbs., was started in the morning and was ready to pour before the "whistle blew" that evening.

GET THIS BULLETIN

QUIK-SETT NB (No Bake)

Get the whole story on this new development in no-bake sand binders. Whether or not you have used or are now using this type of material, you will be interested in what Quik-Sett NB will do—the many advantages it has over conventional no-bake binders. Write for your copy of the new bulletin describing Houghton Quik-Sett NB. And if you wish, we'll gladly *show* you what it will do in your foundry—on one of your jobs. E. F. HOUGHTON & CO., 303 W. Lehigh Ave., Philadelphia 33, Pa.

Houghton

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